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Royal and District Agricultural Societies' 50-Acre Crop Competitions, 1939.

I. THOMAS, Superintendent of Wheat Farming.

The 50-acre Crop Competitions were inaugurated in this State during 1921 with the object of improving the farming methods of the State by creating a spirit of healthy rivalry among farmers and by focussing attention upon the methods of the successful competitors. As can be readily understood, there is considerable variation in rainfall, soil, etc., in a wheat-belt so widely extended as it is in this State. For these reasons the wheat-belt has been sub-divided into eight zones, in such a manner that districts having similar interests and climatic conditions have been grouped together, in this way farmers may compete with each other more equitably. The accompanying map shows the eight zones referred to.

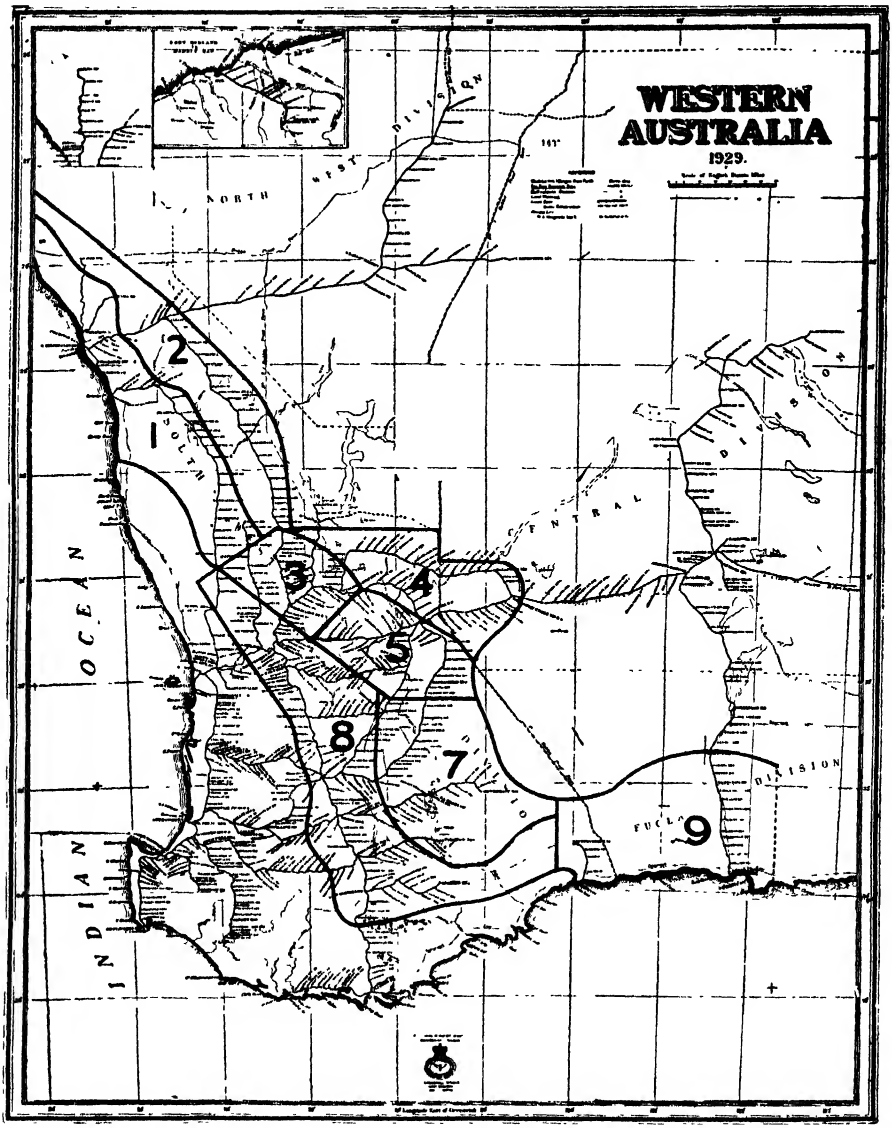
Entry for these competitions is made through the affiliated district Agricultural Societies; the first and second prize winners of these district competitions automatically become eligible to compete for the prizes offered by the Royal Agricultural Society, provided that these competitions are conducted under the conditions laid down by that Society. Where there is no local agricultural society, or the society does not conduct a competition, any farmer who desires to participate in the zone competition may do so by entering direct with the Royal Agricultural Society.

In each zone the Royal Agricultural Society awards a championship prize of £10 and a second prize of £2 10s. and in addition a special prize of £5 5s. is awarded to the competitor who obtains the highest calculated bushel yield per acre for all zones.

The conditions of the competitions require that the crop shall be grown on fallowed land; shall be not less than 50 acres in a compact and unbroken plot of one variety and shall be judged under the following scale of points:

Yield	50 points
Freedom from weeds	10 points
Freedom from disease	10 points
Freedom from admixture	15 points
Evenness of growth	15 points
Total	100 points

The points for yield are determined by taking quadrate samples systematically throughout the crop, threshing and weighing the grain, then the yield per acre is calculated and one point is allotted for each bushel yield per acre.



Since the inception of these competitions, the Judges have been Departmental Officers attached to the Wheat Branch. All the competing crops in any one zone are inspected and the awards made by the same judge.

The Season.—Following a period of four years of low rainfall, the 1939-40 season opened well with heavy rains in January when the wheatbelt, excepting the north-eastern portion, received falls well above the average. This was followed

by further heavy rains during the early part of February, when the whole of the wheatbelt benefited. These excellent falls served to replenish the supplies of subsoil moisture which were sadly depleted after the past four dry seasons.

Very little rain fell throughout the wheatbelt during the months of March and April. However, good falls were received during the early part of May, followed by warm conditions until the end of the month when further falls were recorded. These good rains resulted in an excellent germination of all crops.

The favourable seasonal conditions continued until the end of August, when a very dry September was experienced with the result that crops in the eastern portion of the wheatbelt began to suffer. Good rains during October relieved the position and the season finished very satisfactorily with average falls during November. The more westerly portions of the wheatbelt received excessive rain, but, generally speaking, the season can be considered as being very satisfactory.

A severe epidemic of rust occurred in the lower southern portion of the wheatbelt and this reduced both the yield of the competition crops and also the number of competitors in these areas.

The detailed awards made by the judges in the different zones are as follow:—

ZONE 1.

Judge: N. Davenport, Agricultural Adviser.

Competitors: Carnamah 5, Moora 5, Royal 1, Total 11.

The rainfall recorded at the centres concerned was as follow:—

	Jan	Feb	Mar	Apl	Growing Period May	June	July	Aug	Sept	Oct	Total.	Nov	Dec	Total.
Carnamah	96	235		13	281	593	333	235	13	125	1,580	41		1,965
Three Springs	116	307	32	4	197	503	324	243	16	132	1,415	21	2	1,897
Moora	183	375	1	64	380	389	539	333	19	99	1,759	155	2	2,539
Miling	148	332	65		293	410	470	301	13	111	1,598	*		*

* Not available.

The awards and cultural details of the leading crops are set out below:—

CARNAMAH AGRICULTURAL SOCIETY.

Competitor	Address	Variety	Yield (1 pt. per Bushel)	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth	Total
			50 points	10 points	10 points	15 points	15 points	100 pts
Forrester, J. K.	Carnamah	Merredin	35	8	9	14	14	80
McDiamond, R.	do	Benubbin	32	9	8	14	13	76
Clark, R. W.	do	Nabawa	28	9	9	14	12	72
Gersch, H. E.	Winchester	Dan	27	9	9	13	14	72
Niven, R.	Carnamah	Merredin	29	9	9	14	12	73

Mr. J. K. Forrester's crop of Merredin was grown on red-brown loam which originally carried York gum, salmon gum and black wattle. The land was ploughed during July, 1938, and cultivated with a disc implement during August. A rigid tyne implement was used for cultivating during October and February. The crop was sown on 20th May with a rigid tyne cultivator-drill and harrowed immediately afterwards. Seed and superphosphate were applied at 45 lb. and 130 lb. per acre respectively.

The crop of "Benubbin" entered by Mr. M. McDiamond was grown on salmon gum and York gum country which had been under cultivation for a number of years. It was ploughed during early September, 1938, with a disc cultivating implement and cultivated with a spring tyne implement during October, 1938, February, 1939, and immediately prior to seeding. A combined cultivator drill was used for the seeding operation which was carried out during the second week of May. Seed and superphosphate were applied at 45 lb. and 90 lb. per acre respectively.

MOORA AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt per Bushel).	Freedom from Weeds	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 points	10 points.	10 points	15 points	15 points.	100 pts.
Ward, H. T. & Son	Namban	Ghurka	38	8	8	12	13	79
Black, T. A	Moora	Bencubbin	34	9	8	14	13	78
Smart, E F.	Miling	Gluclub	32	9	9	13	13	76
Hockridge, W J.	Moora	Sword	28	8	8	14	11	69
Seymour, H.	Miling	Ghurka	27	8	8	12	13	68

The first prize was awarded to Messrs. H. T. Ward and Son's crop of "Ghurka" grown on land originally timbered with York gum and jam. The land was broken up with a rigid tyne implement in early August, 1938, and cross-worked with the same implement in February after heavy rains. It was seeded during the middle of May, using a rigid tyne cultivator-drill and seed and superphosphate were applied at 70 lb. and 100 lb. per acre, respectively.

The crop of "Bencubbin" entered by T. A. Black was grown on land, originally timbered with York gum and salmon gum, which had been cleared for a number of years. It was ploughed during July, 1938, with a mouldboard implement, and cultivated with a springtyne cultivator immediately prior to seeding with a combined cultivator drill during the first week in May. Seed and superphosphate were applied at 60 lb. and 90 lb. per acre respectively.

ROYAL AGRICULTURAL SOCIETY

Competitor	Address	Society.	Variety.	Yield (1 pt per bush)	Freedom from Weeds	Freedom from Disease.	Freedom from Admixture	Evenness of Growth.	Total.
				50 pts	10 pts.	10 pts	15 pts	15 pts	100 pts.
Williamson, A M.	Three Springs	Royal	Merredin	36	9	9	14	13	81
Forrester, J K	Carnamah	Carnamah	do	35	8	9	14	14	80
Ward, H. T., & Son	Namban	Moora	Ghurka	38	8	8	12	13	79
Black, T. A	Moora	do	Bencubbin	34	9	8	14	13	78
McDiamond, R	Carnamah	Carnamah	do.	32	9	8	14	13	76

Mr. A. M. Williamson's crop of "Merredin" which won the zone championship was grown on York gum country which had been under cultivation for a number of years. The land was ploughed in July, 1938, with a disc implement, cultivated with a rigid tyne implement during August and seeded with a rigid tyne cultivator-drill during the third week in May. Seed and superphosphate were applied at 43 lb. and 112 lb. per acre respectively.

ZONE 2.

Judge: F. V. Knapp, Agricultural Adviser.

Competitors: Royal 2, Perenjori 1, Total 3.

The rainfall at Damboring and Perenjori for the year 1939 was as follow:—

	Jan	Feb.	Mar.	Apl	May. (Growing Period)	June	July.	Aug	Sept.	Oct	Total	Nov	Dec.	Total.
Damboring	91	310		37	328	321	279	125	12	63	1,128	119		1,685
Perenjori	175	256	18	3	255	499	344	189	4	132	1,423	49		1,924

Tables showing the judge's awards and cultural details of leading crops are set out below:—

ROYAL AGRICULTURAL SOCIETY

Competitor.	Address.	Society.	Variety.	Yield (1 pt per bush).	Freedom from Weeds.	Freedom from Disease	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts	10 pts.	15 pts.	15 pts.	100 pts.
England, W. H.	Perenjori	Perenjori	Bencubbin	34	8	9	14	14	79
Borrett, R.	Damboring	Royal	do.	32	9	9	13	14	77
Bradford, R	do.	do	Gluclub	20	8	9	12	13	62

Mr. W. H. England's crop of "Benecubbin," which was awarded first place, was grown on land which had previously been timbered with salmon gum and York gum and had been cleared for a number of years. It was ploughed in July with a heavy disc implement and springtyne cultivated in March and again in April. Seed and superphosphate were applied with a combined cultivator drill during early May, the rates being 40lb. and 90lb. per acre, respectively.

The crop of "Benecubbin" entered by R. Borrett, was grown on salmon and York gum timber country, which had been cleared for a number of years. This land was ploughed during June and July with a disc cultivating plough to a depth of 3½ inches and springtyne cultivated in October and again in February. A combined cultivator drill was used for seeding, which was carried out during the middle of May, the rates of seed and superphosphate being 45lb. and 110lb. per acre, respectively.

ZONE 3.

Judge: F. L. Shier, Agricultural Adviser.

Competitors: Dowerin, 2; Ballidu, 7; Wyalkatchem, 7; total 16.

The rainfall recorded at the centres in this zone was as hereunder:—

	Jan	Feb	Mar	Apl	Growing Period May	June	July	Aug	Sept	Oct	Total	Nov	Dec	Total.
Dowerin	31	486	1	66	402	358	353	290	10	118	1,531	227	22	2,364
Wyalkatchem	56	414	5	85	273	260	352	192	17	209	1,303	143		2,006
Dukin	51	305		50	230	212	189	165	10	217	1,023	81	4	1,514
Ballidu	91	343	3	59	322	375	319	162	5	142	1,325	115		1,936
Wongan Hills	73	435		70	343	355	371	259	7	103	1,438	89	2	2,107

The judge's awards, together with cultural details of the leading crops, are set out below:—

BALLIDU AGRICULTURAL SOCIETY

Competitor.	Address	Variety	Yield (1 pt per Bushel)	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth	Total
			50 points	10 points	10 points	15 points	15 points	100 pts.
Knapp, J	Ballidu	Benecubbin	35	9	9	13	14	80
Ackland, J H. (jun)	Wongan Hills	do	27	9	9	14	13	72
Mt Rupert Pastoral Co.	do.	Gluclub	28	9	9	13	13	72
Goodie, H.	Ballidu	Golden King	26	9	8	13	13	69
Petchell, R.	do	Gluclub	25	9	9	13	13	69
Maley, M	do	Benecubbin	25	9	9	13	13	69
Carter, F.	Kondut	do	23	9	8	13	12	65

Mr. J. Knapp's winning crop of "Benecubbin" was grown on gimlet, morrell and York gum timber country which had been cleared for over twenty years. The land was broken up in July with a rigid tyne implement, cultivated in August and February with a springtyne cultivator and seeded during the middle of May with a combined cultivator drill. Seed and superphosphate were applied at 45lb and 90lb. per acre, respectively.

The crop of "Benecubbin" entered by Mr. J. H. Ackland, jnr., was grown on gimlet and morrell timber country which had been cleared for a number of years and cropped on the three-year system. The land was broken up in June with a rigid tyne implement, cultivated in September with the same implement, then harrowed and cultivated again in November and March with a springtyne implement. Seeding was carried out during the third week in May; seed and superphosphate were applied at the rates of 50lb. and 112lb. per acre, respectively.

The Mt. Rupert Pastoral Company's crop of "Gluclub," which tied for second place, was grown on salmon gum, morrell and gimlet timber country that had been cleared for a number of years. It was ploughed in July, 1938, with a mouldboard plough, cultivated in August, ploughed back in September with a disc cultivating plough and again cultivated with a springtyne implement in April. A combined cultivator drill was used for seeding, 60lb. seed and 180lb. superphosphate per acre being applied. The crop was harrowed after seeding in order to destroy the weed growth.

WYALKATCHEM AGRICULTURAL SOCIETY

Competitor	Address	Variety	Yield (1 pt. per Bushel.)	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth	Total.
			50 points	10 points	10 points	15 points	15 points	100 pt
Errey, A. D.	Wyalkatchem	Benubbin	36	9	9	14	14	82
Metcalf, E. A.	do	do	36	9	8	14	14	81
Maitland, C. W.	do	do	29	9	9	14	14	75
Lehman, C. E.	Dukin	Gluclub	27	9	9	14	13	72
Lawrence, A. E.	Wyalkatchem	Bencubbin	28	8	9	14	13	72
Riches, G. H.	do	Nabawa	25	8	9	13	13	68
Geise, E. E.	do	Gluyas Early	20	9	9	14	14	66

The winning crop of "Bencubbin" was grown by Mr. A. D. Errey on old land which had previously been timbered with gimlet and salmon gum. It was ploughed in June, 1938, with a disc plough, cultivated in September with a rigid tyne implement and seeded during early May with a combined cultivator drill. Seed and superphosphate were applied at 45lb. and 112lb. per acre, respectively.

Mr. E. A. Metcalf's crop of "Bencubbin" was grown on old land that had been broken up while dry in August, 1938, with a rigid tyne implement. It was cultivated with the same implement in February and March and seeded during the middle of May with a combined cultivator drill. Seed and superphosphate were applied at 45lb. and 118lb. per acre respectively.

The variety "Bencubbin" also gained third place, the crop being grown by Mr. C. W. Maitland on old land which was ploughed in late June, 1938, with a disc plough, reploughed with the same implement in September and cultivated in March. Seed and superphosphate were applied at 50lb. and 110lb. per acre, respectively.

DOWERIN AGRICULTURAL SOCIETY

Competitor	Address	Variety	Yield (1 pt. per Bushel.)	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth	Total
			50 points	10 points	10 points	15 points	15 points	100 pts.
Willmott, H. I.	Dowerin	Bencubbin	24	9	9	14	13	69
Thomas, T.	do	do	20	8	9	13	13	63

The crop of "Bencubbin" grown by Mr. H. I. Willmott was on land originally timbered with mallee, salmon gum and York gum. It was ploughed in late June, 1938, with a disc plough, cultivated in August and February with a springtyne cultivator and seeded during the third week of May with a rigid tyne cultivator-drill. Seed and superphosphate rates were 45lb. and 112lb. per acre, respectively.

Mr. T. Thomas' crop of "Bencubbin" was grown on mallee and jam timbered country, which had been cleared for a number of years. It was ploughed in July, 1938, with a disc cultivating plough and then ploughed back with the same implement in March. Seed and superphosphate were applied at 42lb. and 90lb. per acre, respectively, during the middle of May, a combined cultivator-drill being used for this operation.

ROYAL AGRICULTURAL SOCIETY

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush.)	Free-dom from Weeds.	Free-dom from Disease	Free-dom from Admix-ture	Even-ness of Growth.	Total
				50 pts.	10 pts	10 pts	15 pts.	15 pts	100 pts.
Errey, A D.	Wyalkatchem	Wyalkatchem	Bencubbin	36	9	9	14	14	82
Metcalf, E A	do.	do.	do	36	9	8	14	14	81
Knapp, J.	Ballidu	Ballidu	do	35	9	9	13	14	80
Ackland, J. H. (jun.)	Wongan Hills	do	do	27	9	9	14	13	72
Mt. Rupert Pastoral Co.	do	do.	Gluclub	28	9	9	13	13	72
Willmott, H I.	Dowerin	Dowerin	Bencubbin	24	9	9	14	13	69
Thomas, T	do.	do	do	20	8	9	13	13	63

ZONE 4.

Judge: W. M. Nunn, Agricultural Adviser.

Competitors: Mt. Marshall, 17; Nungarin and Eastern Districts, 4; Wialki Branch Wheatgrowers' Union, 4; total, 25.

The rainfall recorded at the centres concerned was as follow:

	Jan	Feb.	Mar	Apl	May	June	July	Aug	Sept	Oct	Growing Period Total	Nov	Dec	Total.
Wialki	58	205	3	22	187	256	255	169	12	129	1,008	112		1,408
Beacon	56	348	14	8	184	280	240	157	3	137	1,001	*	*	*
Mandiga	22	259	3	54	130	206	216	140	22	149	863	198		1,399
Bencubbin	22	271	21	60	111	185	181	115	10	131	733	135		1,242
Nungarin	17	317		66	193	236	225	159	10	169	992	147	2	1,541

* Not available

The awards and cultural details of the leading crops are set out below:—

MT MARSHALL AGRICULTURAL SOCIETY

Competitor	Address	Variety	Yield (1 pt per Bushel)	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth	Totals
			50 pts	10 pts	10 pts	15 pts	15 pts	100 pt
Anderson Bros	Wialki	Bencubbin	25	9	9	14	14	71
Stark, J A	Beacon	do	24	8	9	14	13	68
Hawthorne, H W	do	do	23	8	9	14	13	67
Hammond, A	Mandiga	do	22	8	9	14	14	67
Gillett, B M	Bencubbin	do	23	8	9	14	12	66
Shipway, J. B.	Beacon	do	20	8	9	14	12	63
Manton, H. W	do	do	20	9	9	12	12	62
Walters, R J	Bencubbin	do	17	8	9	14	14	62
Gobbart, W J	Gabbin	do	18	7	9	14	12	60
Perry Bros	Bencubbin	Gluyas Early	18	9	7	14	12	60
Hopwood, B W G	do	Bencubbin	18	7	8	14	13	60
Collins, S G.	do	do	18	6	9	14	12	59
Clarke, J A W M	Wialki	do	17	7	9	14	11	58
Burnham, E I	Beacon	do	19	7	9	11	12	58
Taylor, E. A	do	do	16	8	9	13	12	58
Wright, J W	Bencubbin	do	18	6	9	12	12	57
Chamberlain, J. W	Beacon	do	16	6	9	13	11	55

The winning crop of "Bencubbin" entered by Messrs. Anderson Bros., was grown on salmon gum timber country which had been under cultivation for a number of years. It was ploughed in July, 1938, with a disc cultivating plough, cultivated in September with a springtyne implement and again, in April, with a disc cultivating plough. Seeding took place during first week of May, when 40lb. of seed and 90lb. of superphosphate per acre were applied.

Mr. J. A. Stark's crop of "Bencubbin" was grown on salmon gum and pine timber country, which had been cleared for a number of years. It was ploughed in August, 1938, with a disc implement cultivated in October with a springtyne

implement and seeded during the second week of May. Seed and superphosphate were applied at 34lb. and 70lb. per acre, respectively.

The variety "Beneubbin" also gained third place, being entered by Mr. H. W. Hawthorne and grown on land which had originally been timbered with salmon gum and mallee. The land was ploughed during June, 1938, with a disc implement, re-disced in August and then seeded during the latter part of May. Seed and superphosphate were applied at the rate of 30lb. and 90lb. per acre, respectively.

NUNGARIN AND EASTERN DISTRICTS AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth.	Total.
			50 pts.	10 pts	10 pts.	15 pts	15 pts.	100 pts.
Watson Bros.	Nungarin	Beneubbin	26	7	9	14	13	69
Philbey, F. G	do.	Gluyas Early	21	9	9	14	12	65
Creagh Bros	do	Beneubbin	23	7	8	14	11	63
Johnson, J H. & Son	do.	Noongaar	19	9	8	14	13	63

Messrs. Watson Bros. winning crop of "Beneubbin" was grown on old land previously carrying salmon gum and gimlet timber. It was ploughed in July, 1938, with a disc implement, springtyne cultivated in September and March and seeded during the middle of May. Seed and superphosphate were applied at 45lb. and 90lb. per acre, respectively.

The crop of "Gluyas Early" grown by Mr. F. G. Philbey was on old land originally timbered with salmon gum and gimlet. It was broken up in June, 1938, with a rigid tyne implement, cultivated with the same implement in April and then seeded during the middle of May Seed and superphosphate were applied at 50lb. and 112lb. per acre, respectively.

WIALKI BRANCH WHEATGROWERS' UNION

Competitor.	Address.	Variety.	Yield (1 pt per Bushel)	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth	Total.
			50 pts	10 pts	10 pts	15 pts	15 pts.	100 pts
Anderson Bros	Wialki	Beneubbin	25	9	9	14	14	71
Miguel, J. A	do.	do.	23	8	9	13	13	66
Clarke, J. & W. M.	do	do	17	7	9	14	11	58
Arnold, J. P G.	do	Noongaar	15	8	9	14	12	58

Mr. J. A. Miguel's crop of "Beneubbin" was grown on salmon gum, mallee and titree timber country which had been cropped for five years. It was ploughed in June, 1938, and again in July, 1938, with a disc implement and cultivated towards the end of March with a springtyne implement. Seeding took place during the middle of April when 30 lb. seed and 60 lb. superphosphate per acre were applied.

ROYAL AGRICULTURAL SOCIETY

Competitor.	Address	Society	Variety	Yield (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts	10 pts	10 pts	15 pts.	15 pts.	100 pts.
Anderson Bros.	Wialki	Mt Marshall	Beneubbin	25	9	9	14	14	71
Watson Bros.	Nungarin	Nungarin and Eastern Districts	do.	26	7	9	14	13	69
Stark, J. A.	Beacon	Mt. Marshall	do.	24	8	9	14	13	68
Miguel, J. A.	Wialki	Wialki	do	23	8	9	13	13	66
Philbey, F. G.	Nungarin	Nungarin and Eastern Districts	Gluyas Early	21	9	9	14	12	65

ZONE 5.

Judge: W. M Nunn, Agricultural Adviser.

Competitors: Bruce Rock, 8; Royal, 3; total, 11.

The rainfall for the year at the centres concerned is set out below:—

	Jan.	Feb.	Mar.	Apl.	Growing Period May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Bruce Rock	39	380		46	241	207	320	178	17	153	1,116	216	16	1,813
Belka	14	374		54	240	236	335	238	10	220	1,279	*	*	*

* Not available.

The awards and cultural details of the leading crops are set out hereunder:—

BRUCE ROCK AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel)	Freedom from Weeds.	Freedom from Disease	Freedom from Admixture	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts	15 pts.	15 pts.	100 pts.
Ellis, E. G. & M. P.	Bruce Rock	Gluclub	39	8	9	13	13	82
Robinson, W.	Babakin	do.	36	9	9	13	13	80
Strange, P. A.	Bruce Rock	do	35	8	9	14	14	79
Perkins, C. C.	Belka	Bencubbin	34	7	9	14	13	77
Buller, A. M.	Bruce Rock	Gluclub	33	9	9	13	13	77
Wilkins, H. W.	do.	do.	29	8	9	14	14	74
Allen, E. M.	do.	Totadgin	31	8	9	14	11	73
Allen, K.	do.	Noongaar	28	7	8	11	13	67

Messrs. E. G. and M. P. Ellis' crop of "Gluclub" was grown on old land originally timbered with jam, York gum and salmon gum. The land was ploughed in June with a disc implement, rigid tyne cultivated twice in September and seeded towards the end of April. Seed and superphosphate were applied at 50 lb. and 90 lb. per acre, respectively.

The second prize was awarded to Mr. W. Robinson's crop of "Gluclub," grown on country originally timbered with gimlet, salmon gum and York gum. The land was broken up in June with a rigid tyne implement, cultivated with a disc cultivating plough in August and again in March with a rigid tyne implement. Seed and superphosphate were applied at 45 lb. and 90 lb. per acre, respectively.

The crop of "Gluclub" entered by Mr P. A. Strange was grown on country originally timbered with gimlet, morrell and salmon gum, which had been under cultivation for a number of years. The land was broken up in July, 1938, with a rigid tyne implement, cultivated in September and October with the same implement and seeded during the latter part of April. Seed and superphosphate were applied at 50 lb. and 100 lb per acre, respectively.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address	Society	Variety	Yield (1 pt. per bush).	Freedom from Weeds	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts	10 pts	10 pts.	15 pts	15 pts.	100 pts.
Ellis, E. G. and M. P.	Bruce Rock	Bruce Rock	Gluclub	39	8	9	13	13	82
Teasdale, H. W.	Merredin	Royal	Bencubbin	37	8	9	13	14	81
Robinson, W.	Babakin	Bruce Rock	Gluclub	36	9	9	13	13	80
Diver, L. C.	Kellerberrin	Royal	Bencubbin	34	7	9	14	13	77
Kay, J.	Baandee	do.	Noongaar	20	8	9	14	14	65

Mr. H. W. Teasdale's crop of "Bencubbin" was awarded second place in the Zone Competition. It was grown on jam, gimlet and salmon gum timber country which had been under cultivation for a number of years. It was broken up in June with a rigid tyne implement, cultivated with the same implement in September and February and then seeded during the third week in May. Seed and superphosphate were applied at 45 lb. and 100 lb. per acre, respectively.

ZONE 7.

Judge: A. S. Wild, Agricultural Adviser.

Competitors: Lake Grace, 7; Kulin. 11; Kukerin, 7; Royal, 2; total, 27.

The rainfall recorded during the year at the centres concerned was as follow:—

	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Lake Grace	401	228	3	24	456	190	426	155	25	292	1,544	148	.	2,848
Pingaring	145	229		57	335	249	328	195	10	154	1,271	194	*	*
Kulin	40	250	2	27	535	205	352	186	15	289	1,582	224	4	2,129
Kondinin ..	8	261	3	45	328	212	296	144	11	307	1,298	120	1	1,736
Kukerin	427	134	18	25	317	211	485	225	34	239	1,511	136	8	2,259
Dumbleyung ...	224	191	3	25	341	270	489	282	53	205	1,640	105	4	2,192
Tarin Rock	615	173	.	18	440	152	430	226	21	229	1,498	*	*	*
Hyden	161	425	5	37	443	117	328	208	23	241	1,360	240	3	2,231
Karlgarin	48	320	4	39	356	204	327	218	16	[illegible]	1,406	224		2,041

* Not available.

The awards and cultural details of the leading crops are set out below:—

LAKE GRACE AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Carruthers, W.	Lake Grace	Gluclub	36	8	9	13	14	80
Pelham, G. H.	do.	do.	33	9	8	11	14	78
Fleay, N. V. ..	Pingaring	do	36	9	7	12	13	77
Coad, H. J. ...	Lake Grace	do.	32	9	8	13	14	76
Kay, W. .	do.	do.	34	8	8	13	13	76
Darby, A. H .	do.	do	31	8	8	14	13	74
Turner, G.	Pingaring	do.	26	8	8	13	13	68

The winning crop of "Gluclub" entered by Mr. W. Carruthers was grown on land that had previously been timbered with gimlet and had been cleared for a number of years. It was ploughed in June, 1938, with a disc implement, rigid-tyne cultivated in August, September and again in March. A combined cultivator-drill was used for seeding during the last week in April, when seed and superphosphate were applied at 52 lb. and 90 lb. per acre, respectively.

Mr. G. H. Pelham's crop of "Gluclub" was grown on land which had been cleared of salmon gum and mallee timber for approximately 20 years. A mouldboard implement was used for ploughing up the land during June and it was then cultivated with a rigid-tyne implement in August, 1938, and again in early May, 1939. It was planted during the second week of May with a combined cultivator-drill, seed and superphosphate being applied at 62 lb. and 92 lb. per acre, respectively.

The third place went to Mr. N. V. Fleay's crop of "Gluclub," grown on morrell and salmon gum timber country which had been cleared for a number of years. It was ploughed in July, 1938, with a disc implement, spring-tyne cultivated in October and again in April, then seeded during the second week in May with a combined cultivator-drill. Seed and superphosphate were applied at 42lb. and 85lb. per acre, respectively.

KULIN AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety	Yield (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease	Freedom from Admixture	Evenness of Growth.	Total.
			50 pts.	10 pts	10 pts.	15 pts.	15 pts.	100 pts.
Scadding, W. W. M.	Jilakin .	Gluclub	37	9	8	12	13	79
Biglin, H. W.	Kondinin	Bencubbin	34	8	8	14	14	78
Freebairn, R. .	Jilakin	do.	34	9	8	13	13	77
Scadding, N. A.	do. .	Gluclub	35	9	8	12	13	77
Carmody, T. .	do. . .	Sword	35	8	7	13	13	76
Young, A. J. . .	Kondinin	Gluyas Early	31	8	9	14	14	76
Freebairn, F. S.	Kulin Rock	Bencubbin	32	9	8	13	13	75
Parker, C. W. .	Jilakin	do.	32	8	7	13	14	74
Repacholi, D.. .	Kondinin	do. .	30	9	8	13	14	74
Bowey, P. J. .	Kulin	Gluclub .	32	8	7	13	13	73
Sykes, H. J. .	Kondinin .	Bencubbin	29	8	8	14	14	73

The crop of "Gluclub" entered by Mr. W. W. M. Scadding was the second crop on land which had previously been timbered with blackbutt, morrell and Loree. The land was ploughed in July, 1938, with a disc implement to a depth of three inches, disced to a depth of two inches in September, and again, just prior to seeding, with a combined cultivator-drill during the fourth week in April. Seed and superphosphate were applied at 60 lb. and 110 lb. per acre, respectively.

Mr. H. W. Biglin's crop of "Bencubbin" was on old land which had originally been timbered with salmon gum, gimlet and morrell. The land was broken up during June, 1938, with a rigid tyne implement, cultivated with the same implement in August, springtyne cultivated in February and seeded during the last week in April with a combined cultivator-drill. Seed and superphosphate were applied at 50lb. and 95lb. per acre, respectively.

Mr. R. Freebairn's crop of "Bencubbin" was grown on country originally timbered with morrell. It was ploughed in June, 1938, with a disc implement, cultivated with a rigid tyne implement in September, with a springtyne cultivator in February and seeded during the first week in May with a combined cultivator-drill. Seed and superphosphate were applied at 60lb. and 112lb. per acre, respectively.

KUKERIN AGRICULTURAL SOCIETY

Competitor.	Address	Variety	Yield (1 pt per Bushel).	Freedom from Weeds	Freedom from Disease	Freedom from Admixture	Evenness of Growth.	Total.
			50 pts.	10 pts	10 pts	15 pts	15 pts	100 pts.
Bennett, A. F.	Dumbleyung	Gluclub	41	9	9	13	14	86
Faulkner, W. J.	North Kukerin	Bencubbin	38	8	8	13	14	81
English, A R	Kukerin	do.	33	9	8	13	14	77
English, J. C.	Merilup	Gluclub	27	9	8	13	14	71
Fitton, J.	Tarin Rock	do	28	8	7	13	13	69
Gard, T.	Kukerin	do	24	9	8	13	13	67
Kellow, J.	North Kukerin	Bencubbin	23	9	8	13	13	66

Mr. A. F. Bennett's crop, although eligible for entry in the Kukerin Agricultural Society's crop competition, was not eligible for competition in the Zone 7 Crop Competition conducted by the Royal Agricultural Society, owing to the fact that his property is situated in Zone 8.

The winning crop of "Gluclub" entered by Mr. A. F. Bennett was grown on salmon gum, gimlet, morrell and mallee country, which had been cleared for a number of years The land was broken up in early August, 1938, with a rigid tyne implement, cultivated with the same implement in late August, springtyne cultivated three times during late April and early May, and seeded with a combined cultivator-drill during the last week in May. Seed and superphosphate were applied at 60lb and 100lb. per acre, respectively.

The second place went to Mr. W. J. Faulkner's crop of "Bencubbin," grown on salmon gum timber country, which had been cleared for a number of years. The land was broken up in July, 1938, with a rigid tyne implement, cultivated with the same implement in August, late February and early May, and seeded during mid-May with a combined cultivator-drill. Seed and superphosphate were applied at 43lb. and 120lb. per acre, respectively.

Mr. A. R. English's crop of "Bencubbin" was grown on old land which had previously been timbered with York gum, jam and gimlet. The land was broken up during the latter part of June, 1938, with a rigid tyne implement, cultivated with the same implement in August, spring-tyne cultivated in early October, February and again in April. A combined cultivator-drill was used for seeding the crop during the second week of May; seed and superphosphate were applied at 48lb. and 100lb. per acre, respectively.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society.	Variety.	Yield (1 pt. per bush).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Faulkner, W. J.	North Kukerin	Kukerin	Bencubbin	38	8	8	13	14	81
Carruthers, W.	Lake Grace	Lake Grace	Gluclub	36	8	9	13	14	80
Scadding, W. W. M.	Jilakin	Kulin	do.	37	9	8	12	13	79
Biglin, H. W.	Kondinin	do.	Bencubbin	34	8	8	14	14	78
Pelham, G. H.	Lake Grace	Lake Grace	Gluclub	33	9	8	14	14	78
English, A. R.	Kukerin	Kukerin	Bencubbin	33	9	8	13	14	77
Marshall, H. J.	Hyden	Royal	do.	31	9	8	14	14	76
Biglin, E. J.	Karlgarin	do.	do.	31	8	9	14	13	75

ZONE 8.

Judge: F. V. Knapp, Agricultural Adviser.

Competitors: Quairading 10, Toodyay 8, Wickepin 7, Gnowangerup 8, Royal 3, Total 36.

The rainfall for the year at the centres concerned in Zone 8 is set out below:—

	Jan.	Feb.	Mar.	Apl.	Growing Period — May	June	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Quairading	120	306	2	40	463	281	353	232	20	155	1,504	151	5	2,128
Toodyay	58	277	1	16	392	472	522	479	25	121	2,011	172		2,535
Bolgart	60	469	1	13	405	490	480	434	24	86	1,919	76	3	2,541
Wickepin	44	243		25	416	316	449	254	39	258	1,732	97		2,141
Gnowangerup	471	137	20	133	223	204	335	193	30	311	1,305	140	2	2,208
Borden	302	104	7	76	168	120	207	151	35	256	937	121		1,547
Toolibin	183	172	3	19	347	242	407	290	20	166	1,472	52		1,901

The awards and cultural details of the leading crops are set out hereunder:—

QUAIRADING AGRICULTURAL SOCIETY.

Competitor.	Address	Variety.	Yield (1 pt per Bushel)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Blake & Sons	Dangin	Merredin	28	9	8	14	13	72
Powell, G. J.	Quairading	Ranee 4H	27	9	8	14	12	70
Powell, N. F.	do.	do	28	8	7	14	12	69
Ward, A.*	Dangin	Bencubbin	26	8	8	14	13	69
Dall, S. C.	Quairading	Ranee 4H	26	8	7	14	13	68
Durack, F. J.*	do.	Gular	23	9	8	13	12	65
Dall, A. F.	do	do	19	8	8	14	13	62
Baikie, L. M.*	do.	Bencubbin	20	9	6	14	12	61
Dall, R. W.	do.	Gluclub	22	8	7	11	12	60
Shenton, E. G.*	do.	Bencubbin	19	8	7	14	11	59

* Not eligible for the Royal Agricultural Society's Zone 8 Crop Competition

The winning crop of "Merredin" entered by Messrs. Blake & Sons was grown on salmon gum and gimlet land which had been cleared for a number of years. It was broken up in early July, 1938, with a rigid tyne implement to a depth of 3½ inches, cultivated with the same implement in September and springtyne cultivated in April, 1939. The crop was sown during the last week of May with a combined cultivator-drill. Seed was applied at 50 lb. per acre and superphosphate at 100 lb. per acre.

Mr. G. J. Powell's crop of "Ranee 4H" which was awarded second place was grown on land which had previously been timbered with gimlet and salmon gum. It was broken up in July, 1938, with a rigid tyne implement to a depth of 3½ inches and cultivated in September, 1938, and February, 1939, with the same implement. A combined cultivator drill was used for the seeding operation which was carried out during the middle of May. Seed and superphosphate were applied at the rates of 45 lb. and 112 lb. per acre, respectively.

The entry of Mr. N. F. Powell, which tied with that of Mr. A. Ward for third place, was planted on salmon gum and gimlet land. A rigid tyne implement was used for breaking up the land in July, 1938, and the same implement was used

for further cultivations in August and March. The variety "Ranee 4H" was sown with a combined cultivator-drill during the third week of May. Seed and superphosphate were applied at 40 lb. and 120 lb. per acre, respectively.

Mr. A. Ward's crop of "Bencubbin" was also grown on salmon gum and gimlet timber country which had been under cultivation for a number of years. A rigid tyne implement was used for breaking up the land during August, 1938, and the same implement was used for cultivating the land in October (twice) and again in April. A combined cultivator-drill was used for sowing the seed at 60 lb. per acre and the superphosphate at 90 lb. per acre.

TOODYAY AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield (1 pt. per Bushel.)	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts
Erickson, S. U.	Bolgart	Bencubbin	32	9	8	14	13	76
Travers, L. E.*	do.	do	32	8	8	13	13	74
Phillips, J. C.	Toodyay	Waratah	29	8	8	13	14	72
Erickson, S. U.*	Bolgart	Pusa IV.	26	9	9	14	14	72
Drake - Brockman, R.	Toodyay	Ghurka	26	9	9	13	13	70
Hayes, E. D. P.	do	do.	25	9	9	12	13	68
Drake - Brockman, R.*	do.	do.	22	9	9	13	12	65
Pearse, R.	Wattening	Wannon	19	7	7	11	12	56

* Not eligible for the Royal Agricultural Society's Zone 8 Crop Competition.

The winning crop entered by Mr. S. U. Erickson was a crop of "Bencubbin" grown on land which had originally carried white gum and a little York gum. It was ploughed with a mouldboard plough in June, 1938, to a depth of 4½ inches and cultivated with a rigid tyne implement in March, 1939. The crop was sown in early May by means of a combined cultivator-drill, seed and superphosphate being applied at the rate of 50 lb. and 130 lb. per acre, respectively.

"Bencubbin" was the variety grown by Mr. L. E. Travers who gained second place. The land on which this crop was grown had been under cultivation for over 30 years and had originally been timbered with York gum and jam. It was ploughed with a mouldboard plough in late August, 1938, and cultivated with a rigid tyne implement in February, 1939, and again a fortnight before seeding, which was carried out during the early part of June with a combined cultivator-drill. Seed and superphosphate were applied at the rate of 45 lb. and 120 lb. per acre, respectively.

Mr. J. C. Phillips' crop of "Waratah" was on York gum and jam country which was mouldboard ploughed in July, 1939, to a depth of 3½ inches. No further cultivation was given and the seed was sown during the third week of May with a combined cultivator-drill. The rates of seed and superphosphate were 50 lb. and 90 lb. per acre, respectively.

WICKEPIN AGRICULTURAL SOCIETY.

Competitor.	Address	Variety.	Yield (1 pt. per Bushel.)	Freedom from Weeds.	Freedom from Disease	Freedom from Admixture.	Evenness of Growth	Total
			50 pts	10 pts.	10 pts	15 pts.	15 pts.	100 pts.
Hosken, J.	Wickepin	Free Gallipoli	31	9	8	14	14	76
McDougall, K., M., & C.	Tinkurrin	Marathon	30	9	9	14	13	75
Doncon, E. E.	Wickepin	Bencubbin	26	9	8	14	13	70
Cockram & Ballard	Tinkurrin	Dundee	24	8	7	13	13	65
Ballard, D.	do	Bencubbin	20	9	8	14	13	64
Miller, G. H.	Toolibin	Rajah	20	9	8	13	13	63
Fleay, E. H. & Sons	Wickepin	Bencubbin	20	8	8	14	12	62

Mr. J. Hosken's winning crop of "Free Gallipoli" was grown on land which had been cleared for nearly 30 years. It had been originally timbered with mallee, salmon gum and York gum and was the first crop for five years. The land was ploughed in July with a mouldboard plough, cultivated in October and March with a springtyne implement, and planted with a combined cultivator-drill during the third week of May, using 60 lb. seed and 90 lb. superphosphate per acre.

The second prize was awarded to Messrs. McDougall's crop of "Marathon" which was on morrell and York gum country that had been cleared for a number of years. It was ploughed in June with a mouldboard plough, and cultivated in October and April with a springtyne implement. A combined cultivator drill was used for seeding the crop during the middle of May, when seed and superphosphate were applied at the rates of 60 and 120 lb. per acre, respectively.

Mr. E. E. Doncon's crop of "Bencubbin" was grown on land which had been originally timbered with York gum, salmon gum and white gum, together with a little morrell and jam. It had been cleared for a number of years and is worked on a three-year rotation. During June, 1938, the land was ploughed with a disc cultivating plough and cultivated in September and March with a springtyne implement. Seeding operations were carried out during the middle of May with a combined cultivator drill; seed and superphosphate were applied at the rates of 50 lb. and 90 lb. per acre, respectively.

GNOWANGERUP AGRICULTURAL SOCIETY

Competitor	Address	Variety	Yield (1 pt. per Bushel.)	Freedom from Weeds	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Bagnall, E	Borden	Sword	33	9	8	14	14	78
Thompson & Hill	Gnowangerup	Rajah	34	8	8	13	14	77
Moore, Owen	do.	Yandilla King	33	9	7	14	14	77
Wellard & Wellard	do	Bencubbin	32	9	7	14	14	76
Badman & King	South Borden	Ghurka	32	9	8	12	14	75
Pozzi, R.	Gnowangerup	Free Gallipoli	33	8	7	13	14	75
Parnell, R	do	do	31	9	6	14	13	73
Formby & Co., Ltd.	do	Bencubbin	27	9	5	14	12	67

Mr. E. Bagnall's crop of "Sword" was grown on land that had been recently cleared of yate and jam timber. It was ploughed in August with a mouldboard plough and cultivated in May with a springtyne implement. Seeding operations were carried out during early June with a combined cultivator-drill, seed and superphosphate being applied at 45 lb. and 90 lb. per acre, respectively.

The crop of "Rajah Improved No. 3" entered by Messrs. Thompson & Hill was grown on salmon gum timber country which had been cleared for ten years and worked on a four-year rotation. It was ploughed in July, 1938, with a mouldboard plough to a depth of approximately 3½ inches, then springtyne cultivated in September and February. Seeding was carried out during the second week of May with 45 lb. seed and 120 lb. superphosphate per acre respectively.

Mr. Owen Moore's crop of "Yandilla King" was grown on morrell, York gum timber country which is worked on a three-year rotation and which had been cropped six times previously. It was ploughed in late August, 1938, with a mouldboard plough, cultivated five times with a springtyne implement during 1939, and seeded during the second week of May with a disc drill. Seed and superphosphate were applied at 58 lb. and 104 lb. per acre, respectively.

ROYAL AGRICULTURAL SOCIETY.

Competitor.	Address.	Society	Variety	Yield (1 pt per Bush.)	Freedom from Weeds	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.
				50 pts	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.
Bennett, A. F.	Dumbleyung	Royal	Gluclub	41	9	9	13	14	86
Bagnall, E.	South Borden	Gnowangerup	Sword	33	9	8	14	14	78
Moore, Owen	Gnowangerup	do.	Yandilla King	33	9	7	14	14	77
Thompson and Hill	do	do.	Rajah	34	8	8	13	14	77
Erickson, S. W.	Bolgart	Toodyay	Bencubbin	32	9	8	14	13	76
Prideaux, J. S.	Noman's Lake	Royal	do.	31	9	9	14	13	76
Hosken, J.	Wickepin	Wickepin	Free Gallipoli	31	9	8	14	14	76
McDougall, K., M. and C	Tinkurrin	do.	Marathon	30	9	9	14	13	75
Phillips, J. C.	Toodyay	Toodyay	Waratah	29	8	8	13	14	72
Blake & Sons	Dangin	Quairading	Merredin	28	9	8	14	13	72
Gilchrist, W. H.	Weden	Royal	Bencubbin	27	9	8	14	14	72
Powell, G. J.	Quairading	Quairading	Ranee 4H	27	9	8	14	12	70

The crop which won the zone championship was entered by Mr. A. F. Bennett of Dumbleyung and was of the variety "Gluclub." This crop was grown on salmon gum, morrell, black mallee and gimlet country which had been under cultivation for 30 years and is worked on a five-year rotation. It was broken up in August, 1938, with a two-way cultivation, with a rigid tyne implement, cultivated in April and May with the same implement and seeded during the later part of May with a combined cultivator drill. Seed and superphosphate were applied at 60 lb. and 100 lb. per acre respectively.

ZONE 9.

There was only one entry in this zone, Mr. F. E. Daw, of Ravensthorpe, and this competitor was forced to withdraw his crop on account of it being badly affected with the disease "rust."

COMPETITORS.

There were 129 competitors in this year's crop competition, 118 entered through the seventeen District Agricultural Societies and 11 entered direct with the Royal Agricultural Society

The following table shows the number and the average yield obtained each year since the competitions were inaugurated:—

Year.	Number of District Agricultural Societies Competing.	Number of Competitors.	Average Yield of Competitors.	Average Yield for State.
			bushels.	bushels.
1921	...	15	25·0	10·4
1922	..	32	24·0	8·9
1923	12	82	29·0	11·4
1924	15	70	31·0	12 8
1925	13	59	22 5	9·7
1926	11	99	24·5	12·0
1927	10	100	26 9	12 1
1928	13	114	22·5	10·1
1929	12	156	21 7	11·0
1930	15	165	27·4	13 3
1931	13	110	27·4	13·1
1932	17	168	29 3	12 3
1933	17	130	27·2	11·7
1934	17	114	26·8	9·8
1935	16	97	24·8	9·2
1936	12	80	21·0	8·4
1937	15	138	25·7	11·9
1938	17	120	26 3	11 3
1939	17	129	27 5	12·6*

* Estimate.

"Bencubbin" was again the most outstanding variety in the competitions, comprising 60 of the 129 competing crops and giving an average yield of 26.3 bushels per acre. This variety also won seven of the seventeen district competitions as well as three of the seven zone championships. Twenty-five entries were of the variety "Gluclub," which was placed first in four district competitions, and three zone championships. The only other variety to win a zone champion-

ship was "Merredin," which also won three district competitions out of four entries. The number of entries of each variety was:—"Bencubbin," 60; "Gluclub," 26; "Ghurka," 6; "Merredin," "Gluyas Early" and "Noongaar," 4; "Free Gallipoli," "Sword," and "Ranee 4H," 3: "Rajah," "Gular" and "Nabawa," 2; "Yandilla King," "Totadgin," "Marathon," "Waratah," "Dan," "Golden King," "Pusa IV," "Dundee" and "Wannon," 1.

YIELDS.

The special prize of £5/5/ for the competitor obtaining the highest calculated yield per acre was awarded to Mr. A. F. Bennett, of Dumbleyung, who produced a calculated yield of 41 bushels per acre.

The winners of this prize since 1925 are as follows:—

Year	Winner	Bush. per acre.
1925	Hebiton & Sons, Three Springs—Nabawa	34
1926	Cumming Bros., Carnamah—Yandilla King	38
1927	A. W. Parkinson, Gnowangerup—Yandilla King ...	40
1928	A. W. Parkinson, Gnowangerup—Yandilla King ...	40
1929	C. E. Cockram, Pallinup—Yandilla King	46
1930	C. Smith & Sons, Yarding—Gluclub	43
1931	H. O. Beeck, Gnowangerup—Yandilla King	42
1932	F. S. Freebairn, Jilakin—Gluclub	47
1933	D. Davis, Gnowangerup—Bencubbin	43
1934	C. E. Cockram, Pallinup—Free Gallipoli	40
1935	E. Davis, Gnowangerup—Bencubbin	41
1936	C. E. Cockram, Pallinup—Free Gallipoli	30
1937	A. R. English, Kukerin—Bencubbin	41
1938	A. J. Tonkin & Sons, Coomberdale—Bencubbin ...	38
	B. J. Edmonds, Calcarra—Bencubbin	38
	R. G. Bennett, Dumbleyung—Gluclub	38
1939	A. F. Bennett, Dumbleyung—Gluclub	41

Of the 129 crops in this year's competition, 38 were calculated to yield 24 to 29 bushels, 40 from 30 to 35 bushels, 11 from 36 to 39 bushels, and one 41 bushels, per acre.

The list of competitors who obtained 35 bushels and over is given below.

Zone.	Competitor.	Address.	Society.	Variety.	Calculated Yield.
					bushels.
8	Bennett, A. F. ...	Dumbleyung ...	Kukerin ...	Gluclub ...	41
5	Ellis, E. G. & M. P. ...	Bruce Rock ...	Bruce Rock ...	Gluclub ...	39
1	Ward, H. T. & Son ...	Namban ...	Moora ...	Ghurka ...	38
7	Faulkner, W.	North Kukerin	Kukerin ...	Bencubbin ...	38
5	Teasdale, H. W. ...	Merredin ...	Royal ...	Bencubbin ...	37
7	Scadding, W. W. M. ...	Jilakin ...	Kulin ...	Gluclub ...	37
1	Williamson, A. M. ...	Three Springs...	Royal ...	Merredin ...	36
3	Errey, A. D.	Wyalkatchem...	Wyalkatchem	Bencubbin ...	36
3	Metcalf. E. A. ...	Wyalkatchem...	Wyalkatchem	Bencubbin ...	36
5	Robinson, W.	Babakin ...	Bruce Rock ...	Gluclub ...	36
7	Carruthers, W. ...	Lake Grace ...	Lake Grace ...	Gluclub ...	36
7	Fleay, N. V.	Pingaring ...	Lake Grace ...	Gluclub ...	36
3	Knapp, J.	Ballidu ...	Ballidu ...	Bencubbin ...	35
3	Forrester, J. K. ...	Carnamah ...	Carnamah ...	Merredin ...	35
5	Strange, P. A. ...	Bruce Rock ...	Bruce Rock ...	Gluclub ...	35
7	Scadding, N. A. ...	Jilakin ...	Kulin ...	Gluclub ...	35
7	Carmody, T.	Jilakin ...	Kulin ...	Sword ...	35

Local Crop Competitions, 1939.

I. THOMAS, Superintendent of Wheat Farming.

In addition to the 50-acre crop competitions conducted by the Royal and District Agricultural Societies under the zone system, a number of local competitions were conducted and judged by Departmental Officers attached to the Wheat Branch.

The Carnamah, Koorda and Bruce Rock Agricultural Societies conducted fallow and crop competitions, the Wialki branch of the Wheatgrowers' Union conducted a 50-acre crop competition for the Bevan cup (the results for this competition are shown under Zone 4 of the Royal Agricultural Society's crop competition), and the Newdegate branch of the Returned Soldiers' League conducted a fallow, germination and crop competition.

The particulars of the respective competitions are as follows:—

CARNAMAH AGRICULTURAL SOCIETY.

Judge: N. Davenport, Agricultural Adviser.

The rainfall recorded at Carnamah during the year was as follows:—

					Growing Period									
	Jan.	Feb.	Mar.	Apl.	May	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Carnamah	96	235		13	281	593	333	235	13	125	1,580	41		1,965

The judge's awards are shown in the following table:—

CARNAMAH AGRICULTURAL SOCIETY

Competitor.	Address.	Variety	Yield. (1 pt. per bush)	Freedom from Weeds	Freedom from Disease	Freedom from Admixture.	Evenness of Growth.	Total for Fallow	Grand Total.
			50 pts	10 pts	10 pts.	15 pts.	15 pts.	100 pts.	200 pts.
Forrester, J. K.	Carnamah	Merredin	35	8	9	14	14	85	165
Gersch, H. E.	Winchester	Dan	27	9	9	13	14	87	159
Niven, R.	Carnamah	Merredin	29	9	9	14	12	75	148
McDiamond, R.	do.	Bencubbin	32	9	8	14	13	70	146
Clark, R. W.	do.	Nabawa	28	9	9	14	12	72	144

Mr. J. K. Forrester's crop of Merredin was grown on a red brown loam which originally carried York gum, salmon gum and black wattle. The land was ploughed during July, 1939, and cultivated with a disc implement during August. A rigid tyne implement was used for cultivating the fallow during October and February. The crop was sown on May 20th with a rigid tyne cultivator-drill and harrowed immediately afterwards. Seed and superphosphate were applied at 45 lb. and 130 lb. per acre, respectively.

50-ACRE CROP AND FALLOW COMPETITION.

Conducted by Koorda Agricultural Society.

Judge: W. M. Nunn, Agricultural Adviser.

The rainfall recorded at Koorda during the year was as follows:—

					Growing Period.									
	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
Koorda ..	42	283	3	42	213	242	199	129	10	156	949	127	3	1,449

The judge's awards are shown in the following table:—

KOORDA AGRICULTURAL SOCIETY.

Competitor	Address.	Variety	Yield. (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total for Fallow.*	Total.
			50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	200 pts.
Best, R. T.	Koorda	Bencubbin	28	8	9	14	13	88	160
Smith, C. H.	do.	do.	25	8	9	14	13	85	154
Hesford, A. J.	do.	Rajah	23	8	8	13	13	82	147
Price, J. W.	do	Bencubbin	23	6	8	14	13	79	143

* Fallow section judged in March, 1939.

The combined fallow and crop competition was won by Mr. R. T. Best whose competing area was salmon gum, gimlet and titree country which had been cropped for a number of years. The land was ploughed in June, 1938, with a mouldboard plough, springtyne cultivated in February, 1939, and seeded during the middle of May with the variety "Bencubbin." Seed and superphosphate were applied at 48 lb. and 80 lb. per acre, respectively.

Mr. C. H. Smith's crop of "Bencubbin" was grown on salmon gum and gimlet country which had been cropped for many years. The land was ploughed in July, 1938, with a disc implement, cultivated with the same implement in September, springtyne cultivated in late March and seeded during late May with a combined cultivator-drill. Seed and superphosphate were applied at 45 lb. and 112 lb. per acre, respectively.

50-ACRE CROP AND FALLOW COMPETITION.

Conducted by Bruce Rock Agricultural Society.

Judge: W. M. Nunn, Agricultural Adviser.

The rainfall recorded at Bruce Rock during the year was as follows:—

	Jan.	Feb.	Mar	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Total.	Nov.	Dec.	Total.
				Growing Period.										
Bruce Rock	30	380		46	241	207	320	178	17	153	1,116	216	16	1,813

The judge's awards are shown in the following table:—

BRUCE ROCK AGRICULTURAL SOCIETY.

Competitor.	Address.	Variety.	Yield. (1 pt. per Bushel).	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total for Fallow.*	Total.
			50 pts	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	200 pts.
Ellis, E. G. & M. P.	Bruce Rock	Gluclub	39	8	9	13	13	88	170
Simmonds, J.	do.	Bencubbin	28	8	9	12	14	82	153
Boase. E. M.	do.	do.	26	9	9	13	11	78	146
Allen, K.	do.	do.	26	8	9	14	11	82	150
Buller, A. M.	do.	Noongaar	26	8	8	13	12	85	152
Fuchsbickler, M.	do	Totadgin	25	7	9	12	13	80	146
Pimlott, S. H.	Kwolyin	do	24	8	8	12	11	85	148

* Fallow section judged during March, 1939.

The combined fallow and crop competition was won by Messrs. E. G. and M. P. Ellis' crop of "Gluclub," grown on jam, York gum and salmon gum timber country which had been cleared for a number of years. The land was ploughed in June, 1938, with a disc implement, rigid tyne cultivated twice during September and seeded in the last week of April. Seed and superphosphate were applied at 50 lb. and 90 lb. per acre, respectively.

Mr. J. Simmonds' crop of "Benecubbin" was grown on gimlet, morrell and mallee timber country. The land was broken up in June, 1938, with a rigid tyne cultivator, harrowed in August, springtyne cultivated in September and March, and seeded during the middle of May. Seed and superphosphate were applied at 45 lb. and 90 lb per acre, respectively

50-ACRE FALLOW, GERMINATION AND CROP COMPETITION.

Conducted by Returned Soldiers' League, Newdegate.

Judge: A. S. Wild, Agricultural Adviser.

The rainfall recorded during the year at the centres concerned was as follows:—

					Growing Period								
	Jan.	Feb.	Mar.	Apl.	May	June	July.	Aug	Sept	Oct.	Total	Nov	Dec	Total.
Newdegate	256	188	4	74	389	152	320	217	61	318	1,457	144	3	2,126
Lake King	316	223		71	282	196	284	142	15	216	1,135	166		1,911
Lake Camm	628	268	19	53	275	189	309	116	8	212	1,109	118	1	2,196
Holt Rock	385	320		35	255	154	226	125	21	182	963	140		1,843
Lake Magenta	267	211	16	78	272	113	397	159	58	186	1,215	211		1,998

The judge's awards are shown in Table I, page 20.

The cultural details of the leading crops are set out below:

Mr. F. M. McPhee's crop of "Gluclub" was grown on land which was originally timbered with salmon gum, mallee and gimlet, and had been cleared in 1931. The land was ploughed during June, 1938, with a disc implement, cultivated during August, 1938, and February, 1939, with a rigid tyne cultivator, and planted during the third week of May with a combined cultivator-drill. Seed and superphosphate were applied at 48 lb. and 120 lb. per acre, respectively.

The crop of "Benecubbin" entered by Mr. G. H. Atkins was grown on land similar to Mr. McPhee's, which had been cleared for 10 years. The land was ploughed during June, 1938, with a disc implement, cultivated in September and late in August with a rigid tyne implement, and seeded during mid-May with a combined cultivator-drill. Seed and superphosphate were applied at 50 lb. and 95 lb. per acre, respectively.

Mr. G. R. W. Hearn's crop of "Gluyas Early" was on land which had been cleared for a number of years, the original timber being salmon gum and gimlet. It was ploughed during early June, 1938, with a disc implement, rigid tyne cultivated in July, August, late September, and twice again early in 1939. A combined cultivator-drill was used for seeding during the second week of May. Seed and superphosphate were applied at 56 lb. and 112 lb. per acre, respectively.

TABLE I.

50 ACRE FALLOW, GERMINATION AND CROP COMPETITION.

NEWDEGATE RETURNED SOLDIERS' LEAGUE.

Competitor.	Address.	Variety.	Fallow Section.						Germination Section.				Wheat Crop Section.						Grand Total.
			Moisture.	Mulch.	Freedom from Weeds.	Preparation of Seed Bed.	Evenness.	Total.	Evenness of Germination.	Vigour of Growth.	Freedom from Weeds.	Total.	Yield.	Freedom from Weeds.	Freedom from Disease.	Freedom from Admixture.	Evenness of Growth.	Total.	
			40 pts.	10 pts	10 pts.	20 pts.	20 pts.	100 pts.	25 pts.	15 pts.	10 pts.	50 pts.	50 pts.	10 pts.	10 pts.	15 pts.	15 pts.	100 pts.	250 pts.
McPhee, F. M.	Lake Camm	Gluclub	38	9	9	18	18	92	23	13	9	45	25	8	8	10	12	63	200
Atkins, G. H.	Lake King	Bencubbin	37	9	8	19	17	90	23	13	8	44	25	9	8	10	13	65	199
Hearn, G. R. W.	Newdegate	Gluyas Early	36	8	7	19	18	88	22	13	7	42	25	9	9	12	14	69	199
Watson, G. F.	Lake Magenta	Gluclub	36	9	8	18	18	89	22	13	9	44	23	9	7	13	14	66	199
Gillett, S. E. T.	Newdegate	Bencubbin	38	8	7	19	19	91	23	13	8	44	24	7	7	12	12	62	197
Lloyd, E.	do.	Gluyas Early	36	8	7	18	18	87	22	13	7	42	24	8	9	13	14	68	197
Grant, E.	do.	do.	36	8	8	19	18	89	22	12	8	42	24	7	8	13	13	65	196
Hartley, A. H.	do.	Bencubbin	37	9	9	18	18	91	20	12	9	41	22	9	6	13	12	62	194
Hetherington, N.	Lake Camm	Gluyas Early	37	7	8	18	18	88	21	12	9	42	24	9	7	10	14	64	194
Francis, M. A.	Holt Rock	Sword	36	6	7	18	18	85	21	13	8	42	25	8	9	12	12	66	193
Kane, J. H.	Lake Magenta	Bencubbin	37	9	9	18	18	91	23	13	7	43	21	7	7	12	12	59	193
Brooker, H.	Newdegate	Gluclub	37	9	8	18	18	90	22	13	7	42	19	7	6	13	12	57	189
Tuck, G.	South Newdegate	Bencubbin	35	8	9	17	17	86	23	14	9	46	16	8	6	12	13	55	187
Hudson, G.	Lake Magenta	do.	36	8	7	18	18	87	24	13	8	45	15	7	6	13	13	54	186
Thomson, S. L.	Newdegate	do.	36	7	8	17	17	85	23	13	7	43	14	7	6	14	12	53	181

Field Experiments with Wheat and Oats, 1939, at the Agricultural Research Stations.

I. THOMAS, Superintendent of Wheat Farming.

At each of the Research Stations located in the Wheat Belt, field experiments with wheat and oats are conducted each year. These Research Stations are widely separated and embrace a considerable variation of soil and climatic conditions.

The field experiments conducted cover a wide range and include such important phases as fallowing, depth and time of ploughing and frequency of cultivation. The most prolific varieties, the best time to plant, the most economical rates of seed and superphosphate to apply, and the effect of various fungicides upon the yields are also ascertained.

With but one or two minor exceptions the experimental plots are one-eighth of an acre in area. They are long and narrow, being one drill width wide, and measure 833 links by 15 links, and are replicated five times.

They are designed on the "three plot" system, the centre plot of each section (three plots) being the control—thus each varying factor is adjacent to a control plot.

The results of the Merredin and Yilgarn Research Stations are given below.

MERREDIN RESEARCH STATION.

J. H. LANGFIELD, Farm Manager.

This station is located 160 miles from Perth on the Eastern Goldfields Railway, and is approximately in the centre of the main eastern wheatbelt. The major portion of the land is salmon gum and gimlet forest country.

THE SEASON, 1939.

The rainfall recorded at the station during 1939 and the average for the past 27 years is set out below:—

					Growing Period									
Year.	Jan.	Feb.	Mar	Apl	May	June	July.	Aug.	Sept.	Oct.	Total	Nov.	Dec.	Total for Year.
1939		347		54	192	250	242	154	12	169	1,019	169		1,589
Av., 27 years	52	44	105	89	127	181	180	152	84	78	802	41	50	1,183

Heavy rain storms were experienced on the 13th of February when 345 points were registered. Following these rains, no further falls of consequence were registered until early in May, when 165 points were recorded between May 4th and 10th. Until the middle of June fairly dry conditions were experienced, and seeding operations proceeded without interruption, being completed by 31st May.

Germination was excellent over the whole area under crop, and the initial rapid growth was sustained until the end of August. Rainfall during September was well below the average, and the hot, dry conditions checked the growth of all crops. Belated rains early in October, however, relieved the position and the crops matured under satisfactory conditions.

Except where the nature of an experiment required special treatment, the land on which the experimental plots were planted was ploughed to a depth of 3½-4 inches during June, July and the first half of August, 1938, with a disc cultivating

plough. In September the heavy soil was cultivated with a rigid-tyne implement and the lighter soils with a spring-tyne implement. Following the heavy rain storms in February, 1939, the whole area was worked with heavy harrows and seeding operations commenced in the last week of April.

FALLOW v. NON-FALLOW EXPERIMENT.

The object of this experiment is to ascertain the effect of fallowing upon the grain yield of the subsequent wheat crop.

The fallowed plots were ploughed in June, 1938, with a disc cultivating plough, cultivated with a rigid-tyne implement in September and again with the same implement immediately prior to seeding. The non-fallowed plots were ploughed on 15th May, 1939, with a disc cultivating plough and cultivated with a rigid tyne implement immediately prior to seeding.

Planted on 19th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 30th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Per-centage Yields, 1939.	Average Yields per acre, 1925–39.	Per-centage Yields, 1925–39.
	bus. lb.	%	bus. lb.	%
Fallow	22 34	84	21 13	134
Non-fallow	26 54	100	15 46	100

The crops on the fallowed plots during 1939 were very heavy and rank and were severely damaged by storms in November, and in consequence a certain amount of grain was not recovered and this would account at least to some extent for the lower yields being obtained from these plots.

The average results over a period of 15 years, however, show that a definite increase in yield is obtained from planting the wheat crop on fallowed land.

DISC CULTIVATING PLOUGH v. RIGID TYNE CULTIVATOR.

The object of this experiment is to determine the effect of carrying out the initial operation of fallowing using a disc cultivating plough as compared with a rigid tyne cultivator. The resultant grain yield of the wheat crop is taken as a means of comparison.

For the requirements of the experiment, three plots are used, each plot being replicated three times.

Plot 1. Rigid tyne cultivated, once in June, 1938.

Plot 2. Disc cultivated, once in June, 1938.

Plot 3. Rigid tyne cultivated, twice in June, 1938.

After the initial workings which were 3½-4 inches deep, all the plots received similar cultivations.

Planted on 19th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 30th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Per-centage Yields, 1939.	Average Yields per acre, 1938-39.	Per-centage Yields, 1938–39.
	bus. lb.	%	bus. lb.	%
Once Scarified	27 50	97	19 54	98
Disc Ploughed	28 30	100	20 20	100
Twice Scarified	26 22	92	18 58	93

The results for the two years that this experiment has been conducted indicate that there is no significant difference in grain yield between any of the above treatments. However, as the experiment has only been conducted for two years, these results cannot be taken as conclusive.

TIME OF PLOUGHING EXPERIMENT.

The object of this experiment is to ascertain whether the time of carrying out the initial operation of fallowing, viz., ploughing, has any effect upon the yield of the resultant wheat crop.

Planted on 19th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 30th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Time of Ploughing.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1930–39.	Percentage Yields, 1930–39.
	bus. lb.	%	bus. lb.	%
Mid-July, 1938	25 38	102	24 11	95
Mid-June, 1938	25 12	100	25 35	100
Mid-August, 1938	27 14	108	21 2	82

This year the late fallowed plots have shown to advantage; however, the average results over a period of ten years show that appreciably higher yields can be expected when the land is ploughed during the early winter months rather than during the later winter or early spring months.

MULCHING EXPERIMENT.

The object of this experiment is to determine to what extent and under what conditions the spring and summer cultivations of winter fallowed land is profitable.

To meet the requirements of the experiment, three plots were used, one being cultivated prior to seeding only, another cultivated during spring and before seeding, and the third cultivated in spring, again when required during summer, and prior to seeding.

Cultivations given each plot are as follow:—

Plot 1.—Cultivated on May 17th, 1939, with springtyne cultivator.

Plot 2.—Cultivated on September 12th, and again on May 17th, both times with a springtyne cultivator.

Plot 3.—Cultivated on September 12th, February 20th, April 4th, and again on May 17th, the springtyne implement being used each time.

Planted on 18th May, 1939. Superphosphate 112 lb. per acre.
Germinated on 28th May, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1915–39.	Percentage Yields, 1915–39.
	bus. lb.	%	bus. lb.	%
Cultivated in spring after summer rains and before planting	26 58	107	21 18	102
Cultivated in spring and before planting	25 6	100	20 48	100
Cultivated before planting ...	24 24	97	19 50	96

This year's results show a slightly increased yield following the summer cultivations; this increase is possibly due to the heavy rains during February germinating the weeds and thus enabling them to be controlled by the summer

cultivations. The results since the inception of the experiment and experience in other parts of the wheatbelt, however, indicate that summer cultivations are not warranted unless weed growth cannot be controlled by stock, or heavy rain during the summer months has destroyed the soil mulch.

TIME OF PLANTING EXPERIMENT.

The object of this experiment is to determine the most suitable month for planting an early and a mid-season variety of wheat.

To meet the requirements of the experiment the variety Gluyas Early, an early maturing variety, was sown in mid-May, June and July, and the midseason maturing variety Nabawa was sown in mid-April, May and June.

Superphosphate—112 lb. per acre. Variety—Gluyas Early. Seed—45 lb. per acre

Date Planted.	Average Yields per acre, 1939. bus.	lb.	Percentage Yields, 1939. %	Average Yields per acre, 1923–39.* bus.	lb.	Percentage Yields, 1923–39.* %
Mid-June	27	20	92	19	45	88
Mid-May	29	46	100	22	31	100
Mid-July	15	36	52	12	12	54

* Excluding 1936.

Superphosphate—112 lb. per acre. Variety—Nabawa. Seed—45 lb. per acre.

Date Planted.	Average Yields per acre, 1939. bus.	lb.	Percentage Yields, 1939. %	Average Yields per acre, 1929–39.* bus.	lb.	Percentage Yields, 1929–39.* %
Mid-April	32	35	116	22	6	109
Mid-May	28	6	100	20	10	100
Mid-June	21	58	78	15	56	79

* Excluding 1936.

The results obtained this year, together with the average results over a period of 10 years indicate that in general the sowing of an early variety should be completed before the end of May, and a mid-season variety before the middle of May.

RATE OF SEEDING EXPERIMENT.

The object of this experiment is to determine the most economical rate to seed:—

1.—A mid-season. free stooling variety; and

2.—An early, sparse stooling variety of wheat.

The variety Nabawa was used in the first section and the variety Noongaar in the second, both being sown at the rates of 30, 45 and 60 lb. per acre.

FREE STOOLING VARIETY.

Planted on 25th April, 1939. Superphosphate—112 lb. per acre.
Germinated on 14th May, 1939. Variety—Nabawa.

Rate of Seed per Acre.	Average Yields per acre, 1939. bus.	lb.	Percentage Yields, 1939. %	Average Yields per acre, 1913–39.* bus.	lb.	Percentage Yields, 1913–39.* %
30 lb.	30	2	99	18	37	95
45 lb.	30	27	100	19	47	100
60 lb.	30	34	100	19	52	100

* Excluding 1914 and 1931.

SPARSE STOOLING VARIETY.

Planted on 31st May, 1939. Superphosphate—112 lb. per acre.
Germinated on 10th June, 1939. Variety—Noongaar.

Rate of Seed per Acre.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1915–39. bus. lb.	Percentage Yields, 1915–39. %
30 lb.	27 58	95	18 6	95
45 lb.	29 18	100	19 2	100
60 lb.	29 2	99	19 4	100

The results of this experiment indicate that there is no advantage to be gained by sowing more than 45 lb. of graded seed per acre in districts having similar conditions to Merredin.

RATE OF APPLICATION OF SUPERPHOSPHATE EXPERIMENT.

The object of this experiment is to determine the most profitable rate of superphosphate to apply to the wheat crop.

SECTION 1.

Planted on 18th May, 1939. Seed—45 lb. per acre.
Germinated on 28th May, 1939. Variety—Totadgin.

Rate of Superphosphate per Acre.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1929–39.* bus. lb.	Percentage Yields, 1929–39.* %
Nil	23 55	94	13 38	62
150 lb.	25 25	100	22 4	100
75 lb.	30 14	118	20 50	94

* Excluding 1936.

SECTION 2.

Planted on 18th May, 1939. Seed—45 lb. per acre.
Germinated on 28th May, 1939. Variety—Totadgin.

Rate of Superphosphate per Acre.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1929–39.* bus. lb.	Percentage Yields, 1929–39.* %
300 lb.	16 50	70	22 32	101
150 lb.	23 54	100	22 16	100
225 lb.	18 53	78	22 33	101

* 1936 excluded.

This year the plots in Section 2 (heavy rates) lodged badly following heavy rains in November and consequently the yields obtained were considerably reduced as much of the grain could not be recovered. This also applied to the control plot in Section 1 (light rates). Only slight lodging occurred in the plots receiving an application of 75 lb. per acre whilst the unmanured plots were unaffected in this direction.

However, the average results over a period of eight years indicate that the rate of superphosphate can be increased with advantage above 75 lb. per acre. Under present conditions the most economic rate on this class of soil is approximately 100 lb. per acre.

POTASH-NITROGEN EXPERIMENT.

The object of this experiment is to determine the effect upon the wheat crop of the application of:—

(a) a nitrogenous fertiliser;

(b) a nitrogenous plus a potassic fertiliser.

Sulphate of ammonia, a nitrogenous fertiliser, and sulphate of potash, a potassic fertiliser, were used in addition to superphosphate.

Planted on 23rd May, 1939. Seed—45 lb. per acre.
Germinated on 2nd June, 1939. Variety—Totadgin.

Rate of Fertiliser per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1932–39.	Percentage Yields, 1932–39
	bus. lb.	%	bus. lb.	%
112 lb. Superphosphate; 112 lb. Sulphate of Ammonia	28 30	102	20 1	101
112 lb. Superphosphate	27 52	100	19 45	100
112 lb. Superphosphate; 112 lb. Sulphate of Ammonia; 56 lb. Sulphate of Potash	27 54	100	19 44	100

Both the results for this year and the average results over the period of six years that the experiment has been conducted show that there is no significant increase in yield from applications of nitrogenous or potassic fertilisers on this type of country.

SEASONAL VARIETY TRIALS.

The objects of this experiment are:—

(a) to ascertain the most suitable month to plant the late, midseason, early and very early maturing varieties of wheat; and

(b) to determine the most prolific of each of the above types.

To meet the requirements of the experiment, three sections were required, viz.:—

1. Section 1, planted in mid April—representing early planting.
2. Section 2, planted in mid May—representing mid-season planting.
3. Section 3, planted in mid June—representing late planting.

In all sections the standard mid-season maturing variety Nabawa was planted as the control plot.

APRIL PLANTING.

Planted on 20th April, 1939. Superphosphate—112 lb. per acre.
Germinated on 14th May, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
Bencubbin	31 9	109	113*
Nabawa	28 29	100	100
Dundee	28 3	98	98†
Fedweb 1	21 9	73	73†
Nabawa	28 50	100	100
Høfed 1	16 14	56	56†

* Average 10 years. † First year of Trial.

MAY PLANTING.

Planted on 15th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 24th May, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.		Percentage Yields, 1939.	Percentage Yields.
	bus.	lb.	%	%
Benecubbin	25	4	110	112*
Nabawa	22	51	100	100
Dundee	17	25	76	76‖
M 47	18	18	81	98§
Nabawa	22	42	100	100
Gluyas Early	20	5	88	108†
Bungulla	23	50	100	115§
Nabawa	23	49	100	100
Totadgin	22	13	93	115‡
M 44	18	45	85	94§
Nabawa	22	6	100	100
Gular	24	27	111	111
M 53	19	42	88	103§
Nabawa	22	14	100	100
M 51	20	42	93	105§
Noongaar	22	22	110	104†
Nabawa	20	24	100	100
Geeralying	14	56	73	95*

* Average, 10 years. † Average, 11 years. ‡ Average, 8 years.
§ Average, 3 years. ‖ 1st year of Trial.

JUNE PLANTING.

Planted on 15th June, 1939. Superphosphate—112 lb. per acre.
Germinated on 28th June, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.		Percentage Yields, 1939.	Percentage Yields.
	bus.	lb.	%	%
M 51	23	54	116	116*
Nabawa	20	38	100	100
M 53	24	16	118	118*
M 52	22	58	112	112*
Nabawa	20	32	100	100
Noongaar	26	38	129	120§
Benecubbin	24	26	123	114‡
Nabawa	19	47	100	100
Bungulla	24	16	123	131†
Merredin	14	58	75	101‡
Nabawa	20	3	100	100
M 47	21	6	105	105*

* 1st year of Trial. † Average, 3 years. ‡ Average, 9 years.
§ Average, 11 years.

In the early planted section, the mid-season variety "Benecubbin" has again shown to advantage this year as it has done for the past 10 years, thus indicating its suitability for planting early in the season.

In the May (mid-season) planted plots the varieties "Benecubbin," "Bungulla," "Noongaar" and "Gular" all yielded well.

The average results over a number of years show that the varieties "Bencubbin," "Gluyas Early," "Bungulla," "Totadgin" and "Noongaar" have consistently yielded well.

In the June (late) planted section, with the exception of "Merredin," all varieties outyielded the control variety "Nabawa." Outstanding were the varieties "Noongaar," "Bungulla" and "Bencubbin," while the new crossbred varieties M51 and M52 also yielded well.

PREMIUM WHEAT VARIETY TRIAL.

The object of this experiment is to determine the most prolific of the Premium Wheat Varieties.

The standard variety "Nabawa" was used as control.

Planted on 26th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 6th June, 1939. Seed—45 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields, 1937–39.
	bus. lb.	%	%
Carrabin	22 35	89	91
Nabawa	25 17	100	100
Pusa 4	23 52	94	95
Pusa 113	15 57	64	73
Nabawa	25 1	100	100
Comeback	15 7	61	63

Of the varieties under trial, "Pusa 4" and "Carrabin" show to advantage; neither, however, equalled the control variety "Nabawa."

FUNGICIDE EXPERIMENT.

The object of this experiment is to determine the comparative effect of copper carbonate and two organic mercury compounds when used as fungicides, upon the germination, growth and grain yields of wheat and oat crops.

Planted on 23rd May, 1939. Superphosphate—112 lb. per acre.
Germinated on 2nd June, 1939. Variety—Totadgin. Seed—45 lb. per acre.

Treatment.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1938–39	Percentage Yields, 1938–39.
	bus. lb.	%	bus. lb.	%
Mercury Compound A	27 36	99	20 28	104
Copper Carbonate	27 58	100	19 45	100
Mercury Compound B	28 3	100	20 5	102

The oat section of this experiment was so severely damaged by storms early in November that it could not be harvested.

The results since the inception of this experiment for both wheat and oats show that there is no significant difference in germination, growth or yield between the various treatments.

YILGARN RESEARCH STATION.

W. A. HUMAN, Farm Manager.

This Station is located at Ghooli Siding, eight miles east of Southern Cross on the Eastern Goldfields Railway, and was established in December, 1926. It contains 4,943 acres, of which 3,500 are first class. The total area at present cleared is 1,635 acres.

THE SEASON 1939.

The following table shows the monthly rainfall registrations for the year, together with the averages for the previous 11 years:—

Year.	Jan.	Feb.	Mar.	Apl.	Growing Period. May.	June	July	Aug	Sept.	Oct.	Total.	Nov.	Dec.	Total for Year.
1939 ...	146	138		71	168	170	210	153	15	138	854	259	5	1,473
Av., 1928–38	48	37	83	96	128	134	118	145	46	68	639	65	46	1,014

The good rains experienced early in May were, unfortunately, followed by a period of six weeks in which no rain of consequence was recorded. As a result, early sown crops germinated well but did not make satisfactory growth, while crops sown after the middle of May germinated very irregularly. Good rains were experienced during July and August and prospects were greatly improved, but the crops were given a further setback by dry conditions during September. The majority of the crops were seriously affected by tipping during September, and the October and November rains were too late to be of any value, except to the very late sown crops.

The paddock which contained the experimental block was originally timbered with salmon gum and gimlet. It was given uniform cultivation, except where the nature of the experiment required special treatment. The land was broken up in July and August, 1938, mainly with a disc cultivating plough. The land was subsequently cultivated with a rigid tyne implement in September, and again with a spring tyne cultivator in February and before seeding.

TIME OF PLOUGHING EXPERIMENT.

The object of this experiment is to determine what effect the time of ploughing (i.e., the initial operation of fallowing) will have on the resultant yield of the wheat crop.

Planted on 24th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 3rd June, 1939. Variety—Gluyas Early. Seed—40 lb. per acre.

Ploughed.	Average Yields per acre, 1939. bus. lb.	Percentage Yields, 1939. %	Average Yields per acre, 1933–39.* bus. lb.	Percentage Yields, 1933–39.* %
March, 1938	14 8	106	10 12	96
June, 1938	13 22	100	10 34	100
August, 1938	13 17	99	10 11	96

* Excluding 1934 and 1936.

Although the average results over the period of the experiment show no great difference between the treatments, the yields from the June ploughed plots are slightly higher than those from either March or August. Generally speaking, it is not possible to plough efficiently during either March or August, and consequently better work can be done during the early winter months.

It is, therefore, recommended as a result of experience at this and other Research Stations, that the initial operation of fallowing, i.e., ploughing, be carried out as early as possible after sufficient rain has fallen to enable the work to be carried out satisfactorily.

DEPTH OF PLOUGHING EXPERIMENT.

The object of this experiment is to determine the most economical depth to plough when fallowing for the wheat crop.

Planted on 23rd May, 1939. Superphosphate—112 lb. per acre.
Germinated on 3rd June, 1939. Variety—Gluyas Early. Seed—40 lb. per acre.

Depth of Ploughing.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1933–39.*	Percentage Yields, 1933–39.*
	bus. lb.	%	bus. lb.	%
2 inches	16 35	94	11 7	98
4 inches	17 36	100	11 18	100
6 inches	17 17	98	11 12	99

* Excluding 1934 and 1936.

The average results over a period of five years show that the depth of ploughing has no significant effect on the yield of the crop. Experience in this and other districts, however, has shown that land which has been ploughed to a depth of less than four inches requires additional subsequent cultivation to maintain the soil mulch and prepare a satisfactory seed bed.

Ploughing to a depth of four inches, when preparing land for the wheat crop is, therefore, recommended as being the most economical.

MULCHING EXPERIMENT.

The object of this experiment, which has been conducted since 1933, is to determine to what extent and under what conditions the cultivation of winter fallowed land during the spring and summer months is profitable.

To meet the requirements of the experiment three plots were treated, as follows:—

Plot 1.—Cultivated prior to seeding only (neglected fallow).

Plot 2.—Cultivated during spring and prior to seeding (ordinary fallow).

Plot 3.—Cultivated during spring, again when required during summer after 25 points of rain or over, and again prior to seeding.

Planted on 23rd May, 1939. Superphosphate—112 lb. per acre.
Germinated on 3rd June, 1939. Variety—Gluyas Early. Seed—40 lb. per acre.

Cultivated.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1933–39.*	Percentage Yields, 1933–39.*
	bus. lb.	%	bus. lb.	%
Before seeding only	12 50	95	10 26	97
In spring and before seeding ...	13 31	100	10 47	100
In spring, after summer rains, and before seeding	15 38	116	11 31	107

* Excluding 1936.

The results of this year's experiment and the average results over the past six years show that there is a slight increase in the wheat yield resulting from summer cultivations of the fallow. Summer cultivation, however, is only likely to be of economic advantage when it is necessary to destroy weeds, and to maintain an adequate soil mulch.

RATE OF SUPERPHOSPHATE EXPERIMENT.

The object of this experiment is to determine the most economical rate of superphosphate to apply to the wheat crop.

Section 1.

Planted on 22nd May, 1939. Seed—40 lb. per acre.
Germinated on 31st May, 1939. Variety—Gluyas Early.

Rate of Application of Superphosphate per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929-39.*	Percentage Yields, 1929-39.*
	bus. lb.	%	bus. lb.	%
Nil	10 32	63	9 42	56
150 lb.	16 45	100	17 14	100
75 lb.	16 43	100	14 42	86

* Excluding 1936 and 1938.

Section 2.

Planted on 22nd May, 1939. Seed—40 lb. per acre.
Germinated on 31st May, 1939. Variety—Gluyas Early.

Rate of Application of Superphosphate per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929-39.*	Percentage Yields, 1929-39.*
	bus. lb.	%	bus. lb.	%
225 lb.	11 9	92	13 55	102
150 lb.	12 5	100	13 39	100
300 lb.	11 12	93	14 0	102

* Excluding 1932 and 1936.

The average results over a period of nine years show that the optimum rate of application of superphosphate to the wheat crop in this district is approximately one hundredweight per acre.

TIME OF PLANTING EXPERIMENT.

The object of this experiment is to determine the most suitable month to plant:—

1.—A mid-season maturing variety.

2.—An early maturing variety.

The varieties used in seeding this experiment were:—

1.—Nabawa (a mid-season maturing variety).

2.—Gluyas Early (an early maturing variety).

Superphosphate—112 lb. per acre. Variety—Nabawa. Seed—40 lb. per acre.

Date Planted.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929-39.*	Percentage Yields, 1929-39.*
	bus. lb.	%	bus. lb.	%
April 16th, 1939	11 39	126	16 55	107
May 16th, 1939	9 14	100	15 48	100
June 16th, 1939	7 33	82	10 14	65

* Excluding 1936 and 1938.

Superphosphate—112 lb. per acre. Variety—Gluyas Early. Seed—40 lb. per acre.

Date Planted.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1929–39.*	Percentage Yields, 1929–39.*
	bus. lb.	%	bus. lb.	%
June 16th, 1939	11 26	84	12 24	74
May 16th, 1939	13 33	100	16 39	100
July 18th, 1939†	6 24	47	6 51	41

* Excepting 1936 and 1938. † July section discarded in 1937 due to destruction by grasshoppers.

This year's results again emphasise the necessity of completing the planting of a mid-season maturing variety before the middle of May, and of an early maturing variety before the end of May.

RATE OF SEEDING EXPERIMENT.

The object of this experiment is to determine the most economical rate of seeding with:—

1.—A mid-season maturing, free stooling variety;

2.—An early maturing, sparse stooling variety.

In section 1 the variety Nabawa was used, and in section 2 the variety Noongaar.

FREE STOOLING VARIETY.

Planted on 18th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 29th May, 1939. Variety—Nabawa.

Rate of Seed per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1937-39.*	Percentage Yields, 1937-39.*
	bus. lb.	%	bus. lb.	%
30 lb.	5 1	81	5 46	87
45 lb.	6 10	100	6 37	100
60 lb.	6 26	104	6 42	101

* Excluding 1938.

SPARSE STOOLING VARIETY.

Planted on 29th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 26th June, 1939. Variety—Noongaar.

Rate of Seed per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1937-39.*	Percentage Yields, 1937-39.*
	bus. lb.	%	bus. lb.	%
30 lb.	9 15	88	7 57	92
45 lb.	10 32	100	8 40	100
60 lb.	11 15	107	9 2	104

* Excluding 1938.

The results of this experiment demonstrate that there is no advantage to be gained by sowing at a greater rate than 45 lb. per acre of graded seed.

POTASH-NITROGEN EXPERIMENT.

The object of this experiment is to determine the effect upon the yield of the wheat crop of an application of:—

(i) a nitrogenous fertiliser;

(ii) a nitrogenous plus a potassic fertiliser;

in addition to the usual application of superphosphate.

For the purpose of the experiment, the fertilisers used were sulphate of ammonia, a nitrogenous fertiliser, and muriate of potash, a potassic fertiliser.

Planted on 22nd May, 1939. Seed—40 lb. per acre.
Germinated on 31st May, 1939. Variety—Gluyas Early.

Rate of Application of Fertiliser per Acre.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Average Yields per acre, 1933–39.*	Percentage Yields, 1933–39.*
	bus. lb.	%	bus. lb.	%
112 lb. Superphosphate; 112 lb. Sulphate of Ammonia	14 46	96	12 9	98
112 lb. Superphosphate	15 22	100	12 26	100
112 lb. Superphosphate; 112 lb. Sulphate of Ammonia; 56 lb. Muriate of Potash	15 25	100	12 9	98

* Excluding 1936.

The average results over the six years this experiment has been conducted, show that there is no economic advantage to be gained from the addition of either a nitrogenous or a nitrogenous plus a potassic fertiliser to the usual dressing of superphosphate.

SEASONAL PLANTING EXPERIMENT.

The objects of this experiment are:—

(i) to ascertain the most suitable month to plant the mid-season, early and very early maturing varieties of wheat;

(ii) to determine the most prolific variety of each of the above types.

To meet the requirements of the experiment, the varieties were sown in three sections, viz.:—

(1) Planted in mid April, representing early planting.

(2) Planted in mid May, representing mid-season planting.

(3) Planted in mid June, representing late planting.

Planted on 15th April, 1939. Superphosphate—112 lb. per acre.
Germinated on 11th May, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
Bencubbin	18 14	115	113*
Gluyas Early	15 55	100	100
Dundee	14 37	92	92†

* Average, 6 years. † First year of trial.

Planted on 16th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 29th May, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.	Percentage Yields, 1939.	Percentage Yields.
	bus. lb.	%	%
M 53	15 36	106	106*
Gluyas Early	14 42	100	100
M 51	16 30	112	112*

* First year of trial.

Planted on 16th May, 1939. Superphosphate—112 lb. per acre.
Germinated on 29th May, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.		Percentage, Yields, 1939.	Percentage Yields.
	bus.	lb.	%	%
Noongaar	17	33	113	89§
Gluyas Early	15	36	100	100
Geeralying	13	10	84	86‡
Bencubbin	17	20	120	112§
Gluyas Early	14	27	100	100
Dundee	12	26	86	86*
M 47	15	25	104	104*
Gluyas Early	14	51	100	100
Nabawa	13	44	92	98§
Bungulla	19	41	131	127†
Gluyas Early	15	2	100	100
Totadgin	15	17	101	103§
M 45	14	46	100	100*
Gluyas Early	14	43	100	100
Merredin	14	35	99	97§

* First year of trial. † Average, 2 years. ‡ Average, 6 years. § Average, 7 years.

Planted on 15th June, 1939. Superphosphate—112 lb. per acre.
Germinated on 26th June, 1939. Seed—40 lb. per acre.

Variety.	Average Yields per acre, 1939.		Percentage Yields, 1939.	Percentage Yields.
	bus.	lb.	%	%
Bencubbin	13	54	116	111‡
Gluyas Early	11	57	100	100
Bungulla	13	46	115	115†
Merredin	11	20	93	94‡
Gluyas Early	12	12	100	100
M 46	12	2	98	98*
M 47	13	18	107	107*
Gluyas Early	12	27	100	100
Noongaar	12	14	98	100‡

* First year of trial. † Average, 2 years. ‡ Average, 7 years.

"Bencubbin" continues to show its superiority in the April planting section, while in both the May and June planting sections "Bencubbin" and "Bungulla" are outstanding. Other good yielding varieties in the May section are "Gluyas Early" and "Totadgin," while "Noongaar" and "Gluyas Early" have yielded well when planted in the June section.

A feature of the experiment this year is the inclusion of a number of fixed crossbred wheats produced by the Department at its Merredin and Wongan Hills Research Stations. The results are for one year only, and therefore no definite conclusions can be drawn regarding them, but several show promise.

A Note on the Salt Tolerance of Wimmera Rye Grass (*Lolium rigidum var. subulatum*).

G. H. BURVILL and L. J. H. TEAKLE,
Plant Nutrition Branch.

Throughout the wheat belt of Western Australia there occur on many farms, areas more or less severely affected by salt, so that their arable value for cereal crops is seriously impaired. On some farms the areas are quite small and confined to strips and patches along creeks, while on others in the lower rainfall areas, *e.g.* Salmon Gums district, the salt affected soil types may cover several hundred acres on a 1,000 acre block. Fortunately, such salt affected areas do not constitute more than a small proportion of the wheat belt as a whole.

Obviously, to make best use of such salt affected areas requires a search for, and investigation of, salt tolerant species of pasture and crop plants, and from experiments and observations in various districts, it has become recognised that Wimmera rye grass can be classed as a relatively salt tolerant plant. It is, moreover, a very palatable and useful pasture plant.

An interesting specific case of the salt tolerance of Wimmera rye grass has been recently furnished from East Katanning, where Mr. A. McD. Sargent has noted that on his property, "Boongadoo," this grass has been established for many years and grows well into several salt creeks. From such situations Mr. Sargent forwarded Wimmera rye grass plants, with the soil in which they were growing adhering to the roots, for a determination of the salt status of the soil. The samples were forwarded through Mr. J. H. R. Brown, Manager of the Bank of New South Wales, Katanning.

The Wimmera rye grass had seed heads up to 18 inches high and represented a very good growth of the plant. The specimens and soil were lifted on 3rd December, 1939.

An examination of the soil adhering to the plant roots showed:—

(a) on the surface a layer ½ to 1 inch thick, of grey to grey brown silty loam, obviously alluvial, over

(b) a variable layer of grey and grey brown sand and sandy loam to the depth of sampling, which was apparently 5 or 6 inches

As the crowns of the plants were above the surface layer, it had apparently been deposited prior to this growing season. This surface layer contained some roots, but dense masses of roots were found in more sandy subsurface, particularly in one very sandy pocket. The whole of the soil forwarded is, no doubt, of recent alluvial origin.

For salt determinations two samples were taken from the surface layer of silty loam, and two from the more sandy subsurface. The results of the analyses were as follows:—

Salt in Soil growing Wimmera Rye Grass.

	Salt (sodium chloride) per cent. of dry soil. (i)	(ii)
(a) Silty loam surface ½ to 1 inch thick	0.63	0.86
(b) Sand and Sandy loam subsurface 1 to 6 inches ..	0.25	0.65

Compared with normal soils, all these figures represent high concentrations of salt, in spite of which the grass has made excellent growth. No doubt, in the low-lying situation occupied by the plants there has been an ample supply of moisture throughout the growing season. It was noticeable, moreover, that the greatest concentration of roots was in the most sandy pockets where the salt concentration would most likely be lowest. Roots were common, however, even in the surface layer, where the salt figures are high, and the success of the grass in such generally saline situations is very encouraging.

On account of the variability in the concentration of salt in the soil adhering to the roots, it is not possible to draw precise conclusions regarding the salt tolerance of Wimmera rye grass, but the evidence indicates that satisfactory growth may be made where the soil salinity is considerably in excess of that tolerated by cereal crops.

In conclusion, attention is directed to the great value of vegetation cover in areas liable to soil salinity. The surface is protected from excessive evaporation with consequent accumulation of salt, and also from damage as a result of wind and water erosion which always occurs on bare unprotected areas. A salt tolerant plant such as Wimmera rye grass not only promotes soil reclamation, but also provides valuable stock feed, and hence some return for the capital invested in the land.

The Cost of Feeding Pure Bred Dairy Cows Under the Australian Official Pure Bred Herd Recording Scheme, Western Australia, 1938-39.

G. K. BARON-HAY, Superintendent of Dairying.

G. SLATER, Recording Officer.

Since 1924 records have been compiled annually from figures obtained from the Pure Breeds Herd Recording Scheme to indicate, as far as can be accurately ascertained under practical conditions, the wide range of feeding costs amongst breeders in the hope that the information may assist in reducing the average cost of feeding by a judicious use of pasture, succulent conserved fodder, and wherever possible, home grown crops.

As the herds under test are spread over practically the whole area of the South-West and extend as far north as Geraldton and west to Doodlakine, it is to be expected that over such a wide range of climatic conditions there should be a considerable variation in the costs of producing milk and butter-fat. For this reason, the costs of various fodders which have to be purchased would vary from farm to farm, but, in order that a comparison may be made regarding the costs of production in the various herds, the average wholesale market price for any foods which may have to be purchased has been used.

It is not intended that these tables should be regarded in the nature of a competition, consequently owner's names have been replaced by a herd letter. Any breeder, however, may obtain the identification of his herd by applying to the Department of Agriculture.

Table 1 gives the prices of feeding stuffs which were adopted in calculating the various costs of feeding.

TABLE 1.

PRICES USED IN VALUATING THE FOODSTUFFS CONSUMED DURING THE YEAR ENDED 30TH JUNE, 1939.

	£	s.	d.
Chaff (per ton) ...	4	3	0
Wheat, crushed (per bushel) ...	0	3	0
Oats, crushed (per bushel) ...	0	2	6
Bran (per bushel) ...	0	1	2
Pollard (per bushel) ...	0	1	2
Silage (per ton) ...	0	10	0
Meggitts Meal (per ton) ...	16	0	0
Proteena (per ton) ...	12	5	0
Cowmeal (per ton) ...	15	0	0
Keymeal (per ton) ...	12	10	0
Meatmeal (per ton) ...	14	0	0
Brewer's Grains (per bushel) ...	0	0	5
Green Lucerne (per ton) ...	1	0	0
Green Maize, Sudan Grass, etc., and Cereal Crops—			
Chaffed (per ton) ...	0	15	0
Grazed (per head per week) ...	0	2	6
Meadow Hay (per ton) ...	3	0	0
Pasture (per head per week)—			
Good green ...	0	2	6
Dry ...	0	1	6

In Table 2 the average results which have been obtained during the past 16 years are set out.

TABLE 2.

PURE-BRED COWS UNDER OFFICIAL TEST—AVERAGE RESULTS OVER A PERIOD OF 16 YEARS.

Year ended 30th June.	Average Milk Yield per Cow.	Average Butter-fat per Cow.	Average Cost of Feed per Cow.	Average Cost of Feed to Produce 1 lb. Butter-fat.	Average Cost of Feed to Produce 1 gall. Milk.	Average Price, Butter-fat per lb.
	galls.	lbs.	£ s. d.	pence.	pence.	pence.
1924 ...	600	319·50	10 4 10	7·70	4·09	19·5
1925 ...	652	308·59	14 13 2	10·77	6·15	17·5
1926 ...	624	312·01	14 14 7	11 15	5·66	19·0
1927 ...	602	290·72	14 10 5	12·00	5·79	19·0
1928 ...	592	280·56	15 11 4	13·34	6·34	19·5
1929 ...	629	295·10	15 1 0	12·24	5·74	20·0
1930 ...	636	294·98	14 10 3	12·74	5·10	19·5
1931 ...	643	301·60	9 14 7	7 74	3·64	16·0
1932 ...	696	318·96	10 18 3	8·21	3·76	14·0
1933 ...	664	308·60	9 2 3	7·08	3·29	11·0
1934 ...	720	333·70	10 2 6	7·28	3·37	10·0
1935 ...	682	326·61	9 18 0	7·34	3·49	12·5
1936 ...	681	320·14	8 14 7	6·54	3·08	12·5
1937 ...	685	309·31	11 5 1	8·73	3·94	14·5
1938 ...	664	306·99	10 19 7	8·58	3·97	15·0
1939 ...	681	310·13	10 13 7	8·26	3·76	16·0

It will be noticed that the average production of butter-fat of all cows is slightly higher than for the previous year, and, as the average cost of feeding is slightly below that for the previous year, the cost of producing 1 lb. of butter-fat has been reduced from 8.58d. to 8.26d. per lb.

Owing to frequently occurring inquiries as to the value of different breeds for the production of milk and butter-fat, the average production and costs of the three breeds under test, namely, the Guernsey, Australian Illawarra Shorthorn, and Jersey, have been collated and compared in Table 3.

TABLE 3.

BREEDS COMPARED AS PRODUCERS OF MILK AND BUTTER-FAT.

Breed.	Average Milk per Cow during 9 months.	Average Test.	Average Butter-fat per Cow during 9 months.	Average Cost of Feed per Cow.	Average Cost of Feed to Produce 1 gall. Milk.	Average Cost of Feed to Produce 1 lb. Butter-fat.
	lb.	%	lb.	£ s. d.	pence.	pence.
A.I.S. (12 herds)	7,544	3·84	299·94	11 9 11	3·66	9·19
Guernsey (7 herds)	6,529	5·26	343·62	11 0 6	4·04	7·70
Jersey (13 herds)	5,781	5·34	308·58	9 1 8	3·77	6·74

The results during 1938-39 are similar to those in previous years, namely, that—from a consideration of the production of butter-fat alone—it would be expected that breeds with a higher average test would be economical producers of butter fat. Other factors, however, should be considered when endeavouring to compare the relative economy of breeds as dairy cattle, such as the extra quantity of milk which may be produced from the larger breeds, particularly the Australian Illawarra Shorthorn, which has a special value for feeding to pigs. Furthermore, the question as to whether or not the farmer is in a position to rear the steers or whether a suitable market exists for vealers must be taken into consideration. Should this be the case, undoubtedly the larger breeds have an advantage.

It is interesting to note that these expectations are borne out in Table 3, as, from the point of view of the production of butter-fat only, the Jersey breed leads followed by the Guernsey and Australian Illawarra Shorthorn. From the point of view of milk production alone, the Australian Illawarra Shorthorn leads, and, when the extra milk produced by this breed is considered, it would be unwise to draw comparisons as to the relative value of any one of these breeds for dairying purposes.

The following Table No. 4 indicates the relative cost of producing milk or butter-fat in dairying districts proper as compared with drier areas as along the Great Southern and the grain growing districts. As would be expected, the cost of production is considerably higher in the latter areas, butter-fat costing approximately 55 per cent more to produce in the dry areas than in the South-West.

TABLE 4.

COST IN LIGHT RAINFALL AREAS COMPARED WITH THE SOUTH-WEST.

Average.	Production.		Cost of Feed for—	
	Milk.	Butter-fat.	1 gal. Milk.	1 lb. Butter-fat.
	lb.	lb.	pence.	pence.
Dry Areas (15 herds)	6,934	298·84	4·38	10·16
Wet Areas (17 herds)	6,661	322·87	3·18	6·56

The following Table No. 5 places the various herds under test in order of merit as profitable butter-fat producers.

TABLE 5.

HERDS IN ORDER OF MERIT AS PROFITABLE BUTTER-FAT PRODUCERS.

Place.	Herd.	District (W = Wet D = Dry)	Breed.	Average Butter-fat per Cow for 9 months.	Available Skim Milk per Cow.	Value of Butter-fat at 1/4 lb.	Value of Skim Milk at 1d. gal.	Gross Return from Butter-fat and Skim Milk.	Cost of Feed per Cow for 9 months.	Profit per Cow.	Cost of Feed to Produce 1 lb. Butter-fat.
						£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	
1	AH	W	A.I.S.	358·09	6,450	23 17 5	2 13 9	26 11 2	6 5 0	20 6 2	4·19
2	E	W	Jersey	339·25	3,805	22 12 4	1 11 9	24 4 1	5 7 10	18 16 3	3·82
3	P	W	do.	346·80	4,558	23 2 5	1 18 0	25 0 5	6 11 9	18 8 8	4·56
4	AG	W	Guernsey	352·53	4,557	23 10 0	1 18 0	25 8 0	7 7 5	18 0 7	5·00
5	B	W	Jersey	354·99	4,139	23 13 4	1 14 6	25 7 10	9 3 4	16 4 6	6·20
6	U	W	Guernsey	328·86	4,157	21 18 5	1 14 10	23 13 3	7 15 2	15 18 1	5·66
7	Z	D	A.I.S.	356·90	6,024	23 15 10	2 10 2	26 6 0	10 11 9	15 14 3	7·12
8	Y	W	Jersey	332·51	3,805	22 3 4	1 11 9	23 15 1	8 4 0	15 11 1	5·91
9	I	D	do.	369·55	4,304	24 12 8	1 15 10	26 8 6	11 1 1	15 7 5	7·18
10	S	W	do.	321·59	3,460	21 8 9	1 8 10	22 17 7	7 19 8	14 17 11	5·97
11	D	W	Guernsey	346·80	4,075	23 2 5	1 14 0	24 16 5	10 0 0	14 16 5	6·92
12	AC	W	A.I.S.	330·79	6,114	22 1 0	2 10 11	24 11 11	7 0 10	14 11 1	5·14
13	O	W	do.	332·88	6,336	22 3 10	2 12 10	24 16 8	7 17 9	13 18 11	5·71
14	G	D	do.	359·45	6,204	23 19 4	2 11 8	26 11 0	13 6 0	13 5 0	8·88
15	M	D	Guernsey	394·58	4,885	26 6 1	2 0 9	28 6 10	15 8 8	12 18 2	9·39
16	H	W	Jersey	298·30	2,978	19 17 9	1 4 10	21 2 7	8 9 1	12 13 6	6·80
17	R	W	Guernsey	329·60	4,132	21 19 5	1 14 5	23 13 10	11 15 7	11 18 3	8·58
18	AD	D	A.I.S.	290·84	4,895	19 7 9	2 0 10	21 8 7	10 10 3	10 18 4	8·73
19	K	D	Jersey	206·93	2,674	13 15 11	1 2 3	14 18 2	4 0 0	10 18 2	4·64
20	AB	D	A.I.S.	321·94	5,059	21 9 3	2 2 2	23 11 5	12 16 4	10 15 1	9·55
21	L	D	Jersey	337·25	3,395	22 9 8	1 8 0	23 17 8	13 8 6	10 9 2	9·57
22	AF	W	do.	278·28	3,502	18 11 0	1 9 2	20 0 2	9 19 5	10 0 9	8·60
23	J	D	do.	300·30	3,535	20 0 5	1 9 6	21 0 11	11 15 5	9 14 6	9·41
24	W	W	do.	250·25	2,532	16 13 8	1 1 1	17 14 9	8 12 5	9 2 4	8·28
25	F	D	A.I.S.	318·50	5,216	21 4 8	2 3 6	23 8 2	15 19 0	7 9 2	12·01
26	AA	D	do.	256·26	4,042	17 1 8	1 13 8	18 15 4	11 10 10	7 4 6	10·82
27	N	D	Guernsey	301·76	3,755	20 2 4	1 11 4	21 13 8	14 9 5	7 4 3	11·51
28	AE	W	do.	287·20	2,994	19 2 11	1 4 11	20 7 10	13 5 0	7 2 10	11·08
29	V	D	A.I.S.	237·60	3,386	15 16 9	1 8 3	17 5 0	12 13 10	4 11 2	12·82
30	X	D	do.	264·4	3,871	17 12 7	1 12 3	19 4 0	14 16 8	4 8 2	13·48
31	T	W	Jersey	257·44	2,175	17 3 3	0 18 2	18 1 5	14 6 10	3 14 7	13·38
32	Q	D	A.I.S.	270·54	4,051	18 0 8	1 13 9	19 14 5	16 10 6	3 3 11	14·22
			Average	310·13	4,389	20 13 5	1 16 7	22 10 0	10 13 7	11 16 5	8·26

Available Skim Milk = (Total Milk — 60 gals. — 10%) — 120 gals.

It will be noticed that the average cost of producing 1 lb. of butter-fat is 8.26d. However, 8 of the 32 herds exceeded 12d. per lb. for the cost of feed to produce 1 lb. of butter-fat and may be regarded as definitely uneconomical herds. The reasons for this are that the majority of these herds were concerned not so much with the production of butter-fat at the ruling rate as with the production of whole milk at whole milk rates, the return from which is approximately double that for butter-fat production, and in consequence reliance in some instances is placed on purchasing fodders rather than on providing these by farming. If these 8 herds were to be excluded, the average production would be approximately 7.04d. per lb. of butter-fat.

The leading herd owned by Messrs. Dunkley Bros., Capel, showed a net profit of £20 6s. 2d., per cow over cost of feed. It will be noted that the cost of producing 1 lb. of butter-fat in this herd is greater than that of the Jersey herd owned by Mr. R. H. Rose, Burekup, occupying second place. The greater return per cow in the case of Messrs. Dunkley Bros.' herd, however, has been due to two factors, namely, the greater value of the skim milk for feeding to pigs and that, by the judicious use of concentrates, the average production of butter-fat was raised yielding a greater profit per cow. Mr. R. H. Rose bred very little concentrates during the year, and, if concentrates had been fed judiciously, there is little doubt that the average production of the herd would have been raised and a greater net profit per cow would have resulted, because, under the conditions of pasturage, some of the highest producing cows would have had difficulty in obtaining all their requirements from this source alone.

As one might expect from the results shown in Table 3, the first six herds in order of merit as butter-fat producers consist of five herds of the Jersey or Guernsey breed, although the leading herd is an Australian Illawarra Shorthorn.

The Table also indicates that the low cost of feeding of a herd does not necessarily mean that the net return from the production is an economical one. This is shown by a comparison of the profit per cow in herd "W" occupying 24th place where the cost of feeding was £8 12s. 5d., the profit per cow being £9 2s. 4d., and another herd, "B," of a similar breed where the cost of feeding was £9 3s. 4d. but the profit per cow £16 4s. 6d. It is extremely doubtful if the cows in herd "W," which averaged only 250 lbs. butter-fat were receiving a ration which would enable them to produce to their maximum capacity, and it is probable that any expenditure on concentrates for these cows would have resulted in an increased butter-fat production, as obviously maintenance requirements already were being supplied.

A study of the Table will disclose similar comparisons between other herds, and in order to determine whether or not the purchase of concentrates is profitable, it is necessary that a Breeder should know the capacity of cows for production and whether sufficient nutrients are being supplied for the cows to produce this yield.

In Table 6 the same herds are arranged in order of merit as profitable milk producers.

It will be noticed that the same herd owned by Messrs. Dunkley Bros., Capel, the cost of feed for which is extremely low as very little concentrates are purchased, is again the most profitable herd from the point of view of milk production, the profit over cost of feeding being £39 5s. 0d. per cow. Here again, the first six herds for milk production conform to what might be expected from a study of Table 3, namely—that five of these herds are of the Australian Illawarra

Shorthorn breed. The figure of 3.76d. per gallon for the average cost of feed is a valuable one and is in close approximation to that obtained during the previous years for which the results have been available.

TABLE 6.

HERDS IN ORDER OF MERIT AS PROFITABLE MILK PRODUCERS.

Place.	Herd.	Breed.	Average Milk per cow for 9 months.	Value of Whole Milk at 1/- per gal.	Cost of Feed per Cow for 9 months.	Profit per Cow.	Cost of Feed to Produce 1 gal. Milk.
				£ s. d.	£ s. d.	£ s. d.	pence.
1	AH	A.I.S. ...	9,100	45 10 0	6 5 0	39 5 0	1·65
2	O	do. ...	8,973	44 17 0	7 17 9	36 19 3	2·11
3	AC	do. ...	8,727	43 13 0	7 0 10	36 12 2	1·94
4	Z	do. ...	8,627	43 3 0	10 11 9	32 11 3	2·94
5	G	do. ...	8,827	44 3 0	13 6 0	30 17 0	3·62
6	P	Jersey ...	6,998	35 0 0	6 11 9	28 8 3	2·26
7	AG	Guernsey ...	6,997	35 0 0	7 7 5	27 12 7	2·53
8	AD	A.I.S. ...	7,372	36 17 0	10 10 3	26 6 9	3·42
9	E	Jersey ...	6,161	30 16 0	5 7 10	25 8 2	2·10
10	U	Guernsey ...	6,552	32 15 0	7 15 2	24 19 10	2·84
11	AB	A.I.S. ...	7,554	37 15 0	12 16 4	24 18 8	4·07
12	B	Jersey ...	6,532	32 13 0	9 3 4	23 9 8	3·37
13	Y	do. ...	6,161	30 16 0	8 4 0	22 12 0	3·19
14	I	do. ...	6,716	33 12 0	11 1 1	22 10 11	3·95
15	D	Guernsey ...	6,461	32 6 0	10 0 0	22 6 0	3·71
16	F	A.I.S. ...	7,507	37 11 0	15 19 0	21 12 0	5·10
17	S	Jersey ...	5,778	28 18 0	7 19 8	20 19 4	3·35
18	R	Guernsey ...	6,525	32 12 6	11 15 7	20 16 11	4·33
19	AA	A.I.S. ...	6,425	32 2 6	11 10 10	20 11 8	4·31
20	K	Jersey ...	4,905	24 10 6	4 0 0	20 10 6	1·96
21	AF	do. ...	5,824	29 2 0	9 19 5	19 2 7	4·11
22	H	do. ...	5,242	26 4 0	8 9 1	17 14 11	3·87
23	J	do. ...	5,861	29 6 0	11 15 5	17 10 7	4·82
24	N	Guernsey ...	6,106	30 11 0	14 9 5	16 1 7	5·69
25	X	A.I.S. ...	6,234	31 3 0	14 16 8	16 6 4	5·71
26	V	do. ...	5,696	28 10 0	12 13 10	15 16 2	5·35
27	Q	do. ...	6,434	32 3 0	16 10 6	15 12 6	5·98
28	W	Jersey ...	4,747	23 7 0	8 12 5	14 14 7	4·36
29	L	do. ...	5,706	28 11 0	14 8 6	14 2 6	6·07
30	AE	Guernsey ...	5,260	26 6 0	13 5 0	13 1 0	6·04
31	M	do. ...	7,361	36 16 0	15 8 8	11 7 4	5·03
32	T	Jersey ...	4,350	21 15 0	14 6 10	7 8 2	7·91
	Average ...	...	6,810	34 1 0	10 13 7	23 7 5	3·76

Coast Disease in Western Australia.

H. W. BENNETTS, Veterinary Pathologist.

Coast disease of sheep in South Australia has been shown recently, by Marston et. al. (1938), to be due to a dual deficiency of copper and cobalt.

The purpose of this article is to give a brief description of investigational work which has demonstrated that an identical disease occurs in Western Australia, and to make recommendations for its control in this State.

From almost the earliest days of settlement it has been known that sheep and cattle could not be run continuously on much of the coastal country, because they developed coast disease, and the general practice has been to graze the coastal country during the autumn and early winter months with stock which have been depastured further inland on "sound" country during the rest of the year.

Although the coastal diseases described in both States have a striking resemblance and the affected country is in both cases of similar geological origin and type, information collected over several years appeared to indicate that there might be differences and suggested the possible presence of complicating factors in Western Australia. It is not proposed to discuss these here, but it did appear imperative, if working on assumption was to be avoided, to have more accurate and detailed information about coast disease in sheep in this State for comparison with the disease of South Australia, before control measures could be recommended.

This view was endorsed by Mr. I. W. McDonald, at that time one of the officers of the Council for Scientific and Industrial Research connected with the South Australian investigation, when he visited Western Australia at the end of 1937.

Since that time the writer has been in close touch with South Australian work and in 1937 spent several days at Robe where every opportunity was given for observing the experimental work being carried out on the property of Mr. R. Dawson. Later in the year Mr. Dawson himself came over here on a visit. Both Mr. McDonald and Mr. Dawson had an opportunity of seeing affected coast country, notably that west of Gingin where experimental work to be described was carried out.

1. THE IDENTITY OF COAST DISEASE OF SHEEP IN WESTERN AUSTRALIA AND SOUTH AUSTRALIA.

As the disease has been so thoroughly studied in South Australia, no systematic investigation was planned or carried out here. The purport of the following experiments and observations was merely to establish the identity of the disease in Western Australia.

(i) *An Experiment on the West Coast.*

In order that the course, symptoms, and pathology of the disease could be studied, arrangements were made to depasture experimental sheep on "Woolca Woolca," a property situate some 70 miles north-west of Gingin. The country is of the typical sand dune type formed from wind blown shell and is known to be "coasty." It is used for grazing cattle during the autumn and early winter months. Sheep have not been carried there for many years but it was reported that sheep would not survive more than several weeks on it.

Thirty acres of typical country, carrying shrubs and perennial grasses, were sheep-fenced and from 22nd May, 1938, seven mated merino ewes from Meckering (Wheat Belt) were depastured thereon. All ewes lambed within a few days of arrival. The flock was maintained there until the completion of the experiment on 10th August, 1939. From 30th July, 1938, nine visits were made at rather irregular intervals, observations recorded, and blood samples collected for haemoglobin and copper determinations.

Both ewes and lambs did very well for about four months. By 20th November, 1938, viz., six months after the commencement of the experiment, all lambs were showing signs of coast disease which developed typically. One died from mis-

adventure, four were killed for postmortem examination when badly affected (two on 20/11/38; one on 22/12/38, and one on 25/1/39) and two were cured and maintained on a copper and cobalt supplement (vide later) being healthy and in good condition at the completion of the experiment eight months later.

The ewes showed no signs of coast disease until they had been on the coast for nine months. The disease then developed typically. Three definitely affected ewes were killed for pathological examination (two on 1/4/39, and one on 10/8/39), one which broke through the fence and was off "Woolca Woolca" for two months during 1939 showed early signs of coast disease at the conclusion of the experiment, and two purposely left until they showed very advanced signs of coast disease were cured and maintained on a copper and cobalt supplement administered from 30/4/39 and 25/5/39 respectively. One ewe died of fly strike in September, 1938.

At the conclusion of the experiment nearly fifteen months after its inception, of the original flock of seven ewes and lambs only two lambs and three ewes remained, and with the exception of one of these ewes, which had strayed for a period on to sound country, all survivors were coasty animals which had been cured and carried through in a healthy state on copper-cobalt supplement. The supplement was administered as a drench twice weekly, the amounts being equivalent to a daily intake of 10 mg. Cu and 1 mg of Co.

The experiment with lambs was particularly significant, as critical experimental conditions were satisfied. Details are given:—

Four lambs which showed a similar early degree of coast disease on 20/11/38 were paired (on haemoglobin figures) and randomised into two groups, one to receive treatment and the other to act as controls. The experiment was commenced on 2/12/38 and was terminated on 10/8/39. Results are tabulated:—

Test Group.		Controls.	
Copper and cobalt supplement as a drench twice weekly.		No treatment.	
Lamb No.	Result.	Lamb No.	Result.
4	Fat, 25th January, 1939. Fat and well-grown at conclusion of experiment on 10th August, 1939 (Haemoglobin: 20th November, 1938 = 9·3; 25th January, 1939 = 14·6; 10th August, 1939 = 13·0)	3	Progressive coast disease. Killed for examination on 22nd December, 1938 in advanced stage of the disease (Haemoglobin: 20th November, 1938 = 9·3)
7	Good condition, 25th January, 1939. Fat and well-grown at conclusion of experiment on 10th August, 1939 (Haemoglobin: 20th November, 1938 = 9·6; 25th January, 1939 = 17·6; 10th August, 1939 = 11·5)	6	Progressive coast disease. Killed for examination on 25th January, 1939, in advanced stage of the disease (Haemoglobin: 20th November, 1938 = 10·2; 25th January, 1939 = 5·7; R.B.C. = 5·3)

Note.—Haemoglobin = grammes per cent. determined by the Newcomer method, the apparatus being standardised gasometrically.

(ii) *Observations and Tests on the West and South Coasts.*

(a) *Examinations of naturally occurring cases of coast disease.*

A number of cases of coast disease were examined on a property ("Doubtful Island Bay") on the south coast. Blood samples were obtained from seven badly affected sheep and one of the worst was killed for pathological examination. All animals examined were anaemic (haemoglobin figures = 7.2, 5.1, 7.2, 7.8, 6.8, 7.6, 8.8).

A stray coasty heifer was examined clinically at "Woolca Woolca." Blood determinations were also made with the following results:—Haemoglobin, 6.2; red cell count, 3.5 million; blood copper 0.03 p.p.m.

(b) *Tests with copper and cobalt supplements.*

During 1938 and 1939, 350-400 cattle depastured on "Woolca Woolca" from March to June-July were given a copper-cobalt supplement in the drinking water while on the coast. The dosage aimed at was about 50 mg. Cu and 1 mg. Co daily. In both years, and particularly during the latter season when the supplement was administered throughout the whole period, the owners are definite from their observations that considerable benefit accrued. The cattle came off the coast in much better health and condition than previously. No trouble was experienced in droving mobs inland (70 miles) as no animals showed any evidence of coastiness. This is in contradistinction to past experience.

During 1938 a test was carried out on the Doubtful Island Bay property, the purpose of which was to ascertain whether it would be possible by means of a copper-cobalt supplement to retain sheep indefinitely there instead of shifting them to sound country after four months, that being the customary practice to avoid coast disease.

A preliminary trial in which a salt lick containing copper and cobalt was supplied to 200 merino wethers, was not an unqualified success. The sheep took lick fairly readily when confined but could not be encouraged to consume adequate quantities under the large paddock conditions obtaining. The results, however, were distinctly encouraging, but in view of practical difficulties in the way of providing supplement in a lick or in drinking water the owner desired to try drenching. The successful control of the disease by means of a drench given at two-monthly intervals on Thistle Island* has been reported (Scott 1938). This method of infrequent drenching was initiated on a large scale at Doubtful Island Bay. Results with some 2,400 merino wethers indicate that periodical drenching, preferably at monthly intervals (Cu 75 mg. Co 20 mg.) will control the disease *on this property* and that sheep so treated can be maintained there in good condition and that they will grow good fleeces. The observations are being continued.

The results of the experiments and observations briefly described above clearly indicate that coast disease of sheep in this State is indentical with that described in South Australia. The course, symptoms and pathology of the disease were as described. Owing to the inaccessibility of both properties on which observations were made, it was not practicable to carry out very detailed haematological investigations (blood examinations) but findings (haemoglobin results, blood smears and some red cell counts) were consistent with those of coast disease in South Australia.

*The disease there, however, is known to be due to an uncomplicated cobalt deficiency.

It was further shown experimentally that sheep badly affected with coast disease rapidly recovered (as when changed to "sound" country) and could be maintained in good health and condition with regular copper and cobalt administrations; it would appear also that the disease may be prevented by copper and cobalt given at much less frequent intervals.

A number of blood copper determinations, notably on sheep at "Woolca Woolca," were carried out by Mr. A. B. Beck, Assistant Animal Nutrition Officer. Low figures, 0.01-0.04 mg. per cent., were repeatedly observed in affected sheep. Animals treated with copper and cobalt, however, showed "normal" figures, 0.07-0.10 mg. per cent.

With regard to coast disease in cattle, although not yet experimentally proved, there is no reasonable doubt that the cause is identical with that of coast disease of sheep. Our own observations have been rather limited but much reliable information is available (notably from W.R.W. from "Woolca Woolca"). The usual symptoms are very similar to those of sheep. Observations indicate that cobalt and copper supplements are beneficial to cattle depastured even for relatively short periods on "coasty" country. Moreover, as is well known in this State, cattle are susceptible to single deficiencies in cobalt (Denmark Wasting Disease) and copper.

2. A DESCRIPTION OF COAST DISEASE.

For the benefit of those who are not familiar with the disease a brief description appears warranted.

(i) *Type of Country, Distribution and Importance of the Disease.*

So far as we are aware the disease is confined to coastal country derived largely from wind borne shell fragments. These form, typically, a fine sandy soil very rich in lime which in older formations may consolidate into limestone.

It has not been practicable to carry out any survey of affected country—observations have been confined to small areas on the west and south coasts, notably on the west coast west of Gingin, around Rockingham, Safety Bay and Mandurah, and further south between Bunbury and Busselton; on the south coast in the vicinity of Bremer Bay and Doubtful Island Bay.

It is known, however, that large areas of the type of country referred to occur along both coasts, these areas extending in places (e.g. "Woolca Woolca") for up to 11 miles inland. The boundary between "coasty" and healthy country is not always clear cut. Further, it has been found of recent years in this State, that large areas of heavily timbered country of totally different character and extending up to 20 miles inland from the coast, are deficient in copper or cobalt. It would appear probable that stock changed from these areas to the coast would develop coast disease more rapidly than stock coming from really "sound" country and thus carrying in their organs sufficient stores of these elements to maintain health for a period. This line of reasoning would explain the rapid development of coast disease in sheep reported from several "coasty" properties and its unexpectedly slow development in experimental sheep at "Woolca Woolca."

A survey of the South-West to determine what areas are affected with deficiencies of copper or cobalt or of both is projected.

In the meantime it may be safely assumed that coastal country derived from wind blown shell on which stock show typical signs of coast disease is affected with a dual deficiency of copper and cobalt.

"Coasty" country has up to the present been used almost exclusively as change country and generally does not carry stock during the winter months when the best feed is available. The solution of the problem of coast disease should make possible a more economic use of large tracts of valuable country in an assured rainfall area.

(iii) Symptoms.

Sheep generally do well for about four months on "coasty" country. Subsequently a malady slowly and progressively develops. This is characterised by depression, wasting and weakness. The eyes are dull and frequently show signs of discharge, the wool appears "dead" and in the late stages there is a marked break near the skin. The affected animal becomes progressively poorer and weaker, and is obviously anaemic, the skin, mouth and membranes of the eye being pale, finally almost white.

Ataxia, due to copper deficiency, may occur in the progeny of ewes depastured prior to lambing on "coasty" country.

Cattle. The usual course and symptoms of the disease are similar to those of sheep. The following description by W.R.W. can hardly be bettered:—

"The cattle become sluggish and lazy; the eyes become sunken and dull; the ears slightly drooped and also the head. The belly soon begins to draw in, the dung is very soft but not actually scoured. In a few cases I have noticed a substance like clotted milk passed in the urine; urine red. Pass dung in small quantities. Cattle showing these symptoms generally will travel up to 12 miles or so in a day; bad cases perhaps only four or five; but only when travelled slowly. If put to sudden exertion or forced to travel quickly they are likely to drop dead. Often very "coasty" cattle, when travelling even slowly, will stop and appear to shiver, which is a sign that if they travel any further they will lie down and die. Cattle that are affected with gradual wasting will be practically free from the effects of coastiness in a few days when shifted off the coast country to further inland, especially if brought on to clay country and clay water (or surface water on clay country)."

In addition to the above, very sudden deaths in cattle, notably of good conditioned cows heavy in calf, have been reported from "Woolca Woolca" and some other "coasty" properties. It would appear very probable that these are actually cases of "falling disease" which commonly occurs in inland copper-deficient areas in the Busselton and Northcliffe districts. Bennetts & Hall (1938). There has been no opportunity of verifying this by pathological examination. A transient red water of cows also is not uncommon in these areas.

Horses are generally said to do well on "coasty" country except that they may develop a condition known locally as "chip chip" which apparently takes the form of an excoriation of the skin of the legs. No cases of this condition have been investigated.

(iii) Post-mortem Appearances.

Sheep. The appearances are those of a starved animal—the carcase is wasted, skeleton light and fragile, and the liver is fatty. On microscopic examination the liver, and, to a less extent, kidneys, show marked fatty changes. Iron deposits (haemosiderin) are found in spleen, liver and kidneys. In our cases, contrary to South Australian findings, haemosiderin was more constant and abundant in the former than in liver and kidneys.

3. RECOMMENDATIONS FOR CONTROL.

The use of copper and cobalt supplement for the control of coast disease may be definitely recommended. The following particulars of dosage and methods of administration are those which have been suggested in response to departmental inquiries and which have given satisfactory results.

The quantities of copper recommended previously, however, are now reduced to conform with those advocated as a result of experimental work, carried out by the Council for Scientific and Industrial Research in South Australia. This has shown that the lower amounts of copper are adequate on the most seriously affected country. The proportion now recommended is five parts of copper sulphate to one part of cobalt chloride.

(a) *Lick.*

The following formula is suggested:—

Copper sulphate (bluestone)	10oz.
Cobalt chloride	2oz.
Common salt	1cwt.

Consumption at the rate of 1oz. per week per sheep and 8oz. for cattle would give an adequate copper and cobalt supplement. These doses should not be greatly exceeded and the amount consumed must be carefully checked by putting out small weighed out quantities. If consumption is excessive, the lick should be diluted proportionately with common salt.

For mixing, the copper and cobalt salts should be dissolved in ½ gallon of water (using a non-metal or unchipped enamel container) and thoroughly incorporated with the common salt until the colour is uniform throughout. A fine grained salt is best and lick troughs should be protected from the weather.

The South Australian work has demonstrated that the consumption of small amounts of copper and cobalt at short intervals give the best results and lick would provide the most effective and economical means of administration.

(b) *Drenching.*

To obtain the best results this should be carried out at frequent intervals. The solution recommended for compounding the lick may be used for the purpose. For use, for drenching, dilute one part of this solution with seventeen parts of water; half a pint added to 8½ pints of water would make a convenient quantity. The dose of the *diluted* solution is half a fluid ounce (15 c.c.), given once a week.

This method would be valuable for the treatment of small numbers, such as a small proportion of the flock not taking lick, as evidenced by absence of response, but would obviously be impracticable as a general measure of control. Under some conditions a compromise may be necessary and less frequent drenching prove a service. It should be remembered that the degree of "coastiness" varies from property to property, and the reported success of infrequent drenching on the "Doubtful Island Bay" property does not necessarily mean that such a method would be successful generally.

The following is the drench actually used on that property:—*

Copper sulphate	½lb.
Cobalt chloride	1oz.
Water	5gall.

Dose — 1 fluid ounce once a month.

*(c) *Drinking water.*

The following concentration has been suggested for drinking water:—

Dissolve copper sulphate	10oz.
Dissolve cobalt chloride	5oz.
In water	1gall.

Add half-pint of the solution to 400 gallons of drinking water.

The consumption by sheep of about 1 gallon and by cattle of about 10 gallons per day would give an adequate supplement. This might be a useful method of administration for sheep during the summer months and throughout the year for cattle.

(d) *Top dressing.*

Where improved pastures have been established on "coasty" country (e.g., on drained swamp country west of Capel), top dressing with copper and cobalt would probably prove the ideal method of controlling the disease. Pending further work, however, no definite recommendations can be made.

4. SUMMARY.

It has been demonstrated that coast disease of sheep in this State is identical with that investigated in South Australia where it was found to be due to a dual deficiency of copper and cobalt.

In this State affected sheep under experimental conditions have been cured and maintained on the coast in good condition by means of regular copper and cobalt supplementation. Indications are that coast disease of sheep and cattle can be controlled under field conditions.

The use of copper and cobalt supplements for the control of coast disease sheep and cattle in Western Australia can be confidently recommended.

5. ACKNOWLEDGMENT.

The writer desires to express his thanks to Messrs. F. A. and W. R. Wedge ("Woolca Woolca") and Messrs. E. A. and A. Y. Hassell ("Doubtful Island Bay") for their co-operation and assistance.

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*It will be noted that the quantities of copper sulphate have not been modified in this instance, the proportion of copper sulphate to cobalt chloride being 8-1 as originally suggested.

Potato Industry—Survey.

Summary of Report by Dr. J. G. Bald submitted to the Australian Council of Agriculture, Standing Committee on Agriculture, Hobart, February, 1940.

In August 1937 the Australian Agricultural Council considered representations for a grant to be made by the Commonwealth to the Potato Industry for research purposes. A Committee was appointed which collated information from each State and interviewed many of those interested in the industry. A comprehensive report has been prepared by Dr. Bald of this Committee, a summary of which report is given hereunder:—

1. *Climate of Potato-growing Areas.*—The conditions best suited to potato-growing are a temperate climate with a uniform supply of moisture during the growing period and absence of severe frosts. Potatoes are grown also in sub-tropical climates, but in the *cooler* part of the year. The times of planting and harvesting are so limited by weather conditions that potatoes must remain a seasonal crop, the bulk of production coming on the market within a few months.

The marginal rainfall limit throughout Eastern temperate Australia is generally between 25 and 30 inches, except when production takes place on swamps or swampy plains, or under irrigation. In Tasmania, the limits are slightly less than average, in Queensland slightly more.

Throughout Australia, the potato crop during the majority of seasons suffers from lack of moisture. Study of rainfall conditions in Tasmania for 25 years 1909-10 to 1933-34 showed that rainfall is one of the major determinants of yield. Although the Tasmanian rainfall is generally considered ample, the best yields were obtained when, during the three summer months, it was above average; however, if it was much more than 20 per cent. above average (4 years in 25), the yield was low.

This preliminary examination suggests that a thorough statistical study of climatic data, yields, etc., would be of value in forecasting production before crops are dug.

2 *Soil Types of the Potato-growing Areas.*—About 75 per cent. of the Australian potato crop is produced on basaltic soils. The next most important soil types are swampy and alluvial soils. The most important belt of alluvial soils on which potatoes are grown (Lockyer Valley, etc., Queensland) is, however, partly derived from basalt.

Overcropping has depleted the basalt soils of minerals and organic matter and has impaired their physical condition. Available minerals most noticeably lacking in many of the worn out soils are calcium and potassium. The loss of calcium increases soil acidity and renders the soils less capable of making mineral nutrients available to the plant. Addition of potassic manures does not compensate for the lack of potassium in the soil, as the added potassium is not retained in a form available to the plant.

Loss of organic matter and calcium leaves the basaltic soils too permeable; they cannot retain sufficient moisture between falls of rain for continuous growth of the potato plant.

Stoppage of the rapid loss of fertility and the economic replacement of lost organic matter and calcium are the first necessary steps in the regeneration of the basaltic soils. Regeneration cannot be accomplished without a revision of the types of agricultural rotations now practised (see under "Agricultural Practice").

The swamp soils present rather different problems. Few are so depleted of minerals and organic matter as the basaltic soils, because heavy manuring has been needed to make many of them productive. In Western Australia, some have been shown by the Department of Agriculture to be deficient in trace elements such as copper, manganese and cobalt.

The alluvial, like the basalt soils, have been severely exploited. Soils less well suited to potatoes than basalts and alluviums have not been overcropped to the same extent, because their initial fertility has not been great enough to allow extensive exploitation.

The manurial needs of potato soils have been broadly defined in most areas, but they need more intensive examination.

Additional surveys of potato soils are badly needed; north-western Tasmania is the only potato-growing area where the soils have been carefully and extensively examined.

3. *Agricultural Methods*.—The bulk of the Australian potato crop is grown on the natural rainfall in association with crops less costly to produce and less demanding of soil fertility. Smaller proportions are irrigated (potatoes may be the only irrigated crop in the rotation) or are grown in association with vegetable crops.

Potatoes have been widely grown in alternation with cereals, as part of a purely agricultural rotation.

The fertility of potato soils has been depleted by both these types of crop, and only a fraction of the organic matter and plant foods lost from the soil has been replaced by manuring and the growing of pastures to carry stock. The rapid loss of soil fertility has been slowed down by alternation of potatoes and cereals with legumes, the ploughing in of green crops, manuring and an increase of stock-raising; but the cropping systems of most potato growers allow the loss to continue. In the long run the most serious problem facing potato-growers is how to adapt their methods to obtain profitable yields without causing any loss of soil fertility. In many instances they are faced, in addition, with an even more difficult problem—how at the same time to put back into the soil some part of what it has lost by overcropping.

It hardly needs saying, that the problem of lost fertility is not a problem merely of the potato-grower. It arises out of the system of exploiting the soil, which has been common to almost the whole farming community in this and other countries opened for cultivation during the last two or three centuries. It is the preliminary stage of the process which in drier areas leads to soil erosion.

The stoppage of depletion of potato soils needs a radical change of farming policy. The change is already being continually advocated by State Agricultural Departments, and is being made by progressive farmers. It involves an increase in productivity and a lessening of acreage of areas sown to potatoes each year, combined with a longer and less exhaustive rotation, adequate manuring, periodical sowing down to pastures, and the carrying of stock.

The principles of such a policy are well enough understood, although details for specific areas need to be studied. Such a policy could quite safely be put into practice over wide areas as quickly as the farmer could be persuaded to change his methods, and the market could absorb the produce of his farm.

A difficulty in the way of the change would be the inability of marginal producers to find capital for stock, improvements, extra equipment, etc. A related difficulty on small holdings would be the inability of the farmer to lengthen his rotation by reducing his acreage, without for a time reducing his net returns below a living wage. A large proportion of potato-growers, however, are in a position to improve their rotational practices.

The actual cultivation of potatoes is on the average much more efficient than the rotational practices. Great improvement on the methods of the more capable farmers is not to be expected. In the selection and care of seed and manuring there is need for improvement on a large proportion of holdings.

The supply of good seed grown under Certification Schemes is making it possible for more farmers to prevent losses from inferior seed stocks. The extension of Certification Schemes is continuing. However, even where they are well established insufficient use is made of certified seed.

Probably the majority of seed is sown without greening by exposure to light. The method of greening in trays or by other means should be widely extended.

Most potato-growers apply less than the optimum amounts of fertiliser, and there is a confusion of methods in its application. Local adaptations of findings on the best methods of applying fertilisers are necessary, as well as on the best amounts to apply. There is much information on methods of application obtained under American conditions, but there cultivation methods are adapted to machine planting.

Extension of the practice of irrigating potatoes, particularly in the Lockyer Valley, Queensland, raises serious problems of management. These need investigation.

In Australia, machinery is seldom used for planting and harvesting even on large holdings. Cultivation practices, spacing, hilling, etc., are adapted to sowing by hand and digging with the fork. Enquiry into the use of machinery and changes in practice that machinery would necessitate would be of value to growers who sow large areas to potatoes. Machinery has often been tested by farmers, but generally under conditions adapted to hand labour.

There is much available information on which improvements in agricultural practice could be based and, where it is not complete, investigation would consist mostly of finding local applications of established principles.

4.—*Diseases and Pests of Potatoes.*—The best estimate the committee has been able to make from the limited data available, of losses due to diseases and pests of potatoes in Australia, is that it approaches 20 per cent. of the total yield to be expected in their absence. This estimate excludes the effects of latent mosaic, due to a virus referred to below. In terms of acreage and production, such losses mean the virtual waste of 25,000 acres of each season's planting and of about 65,000 tons of the production.

(a) Diseases.

The diseases of most importance in Australia may be classified as follows:—

(i) *Virus Disease.—Preventible*: Mainly of three types transmitted in the field by aphides. They alone are estimated to reduce the total yield by 7½ per cent or more, which is equivalent to a total loss on about 10,000 acres or from 25,000 to 30,000 tons in yield. The viruses are carried over from season to season in the tubers.

Virus diseases can be controlled through Certification Schemes. (See later.)

Latent Mosaic: Is carried in almost every tuber of the principal varieties grown here. It causes very slight symptoms or none, but probably causes an overall reduction in yield which is unnoticed because virus-free stocks of the same variety are not available for comparison. Unless occasional virus-free tubers can be found, the only way of getting rid of the disease will be by ceasing to grow the varieties affected.

(ii) *Scab Disease,* of which *Rhizoctonia* scab is most important. The organisms causing these diseases are carried in the soil and on the surface of the tubers, and some affect the tops of the plants as well as the tubers.

In a large measure they can be controlled by proper rotational practices, "dipping" seed tubers in fungicidal solutions, etc.

(iii) *Wilt Diseases,* caused by fungi (*Fusarium, Verticillium,* etc.) and bacteria (blackleg, etc.) which inhabit the soil and are carried inside seed tubers. Their incidence can be reduced by good agricultural practices and selection of seed.

(iv) *Tuber Rots.*—Of these the principal is *Pythium de Baryanum* which is carried in the soil of infected fields in certain districts. It can be eliminated by a period of planting to grass or other non-susceptible crops. The organisms which cause the foliage diseases known as late and early blight also cause tuber rots.

(v) *Foliage Diseases.*—Late blight rarely occurs in epidemic form over large areas, except in northern New South Wales, Queensland and in isolated districts of other States. Early blight is more important because it is more widespread although not so catastrophic. Spraying with copper sulphate mixtures will control these diseases.

(b) Pests.

The Potato Moth is the most serious pest and causes considerable damage, particularly in hot climates and during hot, dry seasons. It attacks the tubers as well as the tops and can go through its life in stored potatoes.

It cannot be controlled by dusts or sprays because the grub lives inside the tissues of the plant and is protected from direct attack.

There is not sufficient information available as to the insect's life history and the multiplication of populations under Australian conditions to guide research into effective control measures.

Hence, field and laboratory studies on the Potato Moth would be of very considerable value; they are a necessary prelude to the discovery of means for reducing its depredations.

Other pests, which include cut worms, Rutherglen bug, thrips, etc., are much less serious than the Potato Moth, and for most of them efficient methods of control are known.

5. *Varieties of Potato Grown in Australia.*—In Australia there has been a natural selection of varieties resulting in the emergence of six, which now make up more than 90 per cent. of the acreage of potatoes. Three (Carman, Brownell and Delaware) originated in America, one (Up-to-date = Factor) in England, one (Bismarck) probably in Germany, and there is one (Snowflake) whose origin is unknown. Of these, Brownell and Delaware are wrongly named, their true names being Adirondack and (probably) Earliest of All.

Each of the main potato-growing regions has its characteristic varieties. These are summarised below:—

Victoria—South Australia: Carman, Snowflake, Up-to-Date.

Tasmania: Brownell, Bismarck.

New South Wales—Queensland: Factor (=Up-to-Date), Carman.

Western Australia: Delaware. (See note page 55.)

Of the six varieties, Carman, Brownell, and Bismarck are grown in spite of their susceptibility to virus diseases and other shortcomings because they produce good quality potatoes. The other three produce average or low quality tubers but they have special virtues, e.g., Snowflake, resistance to many diseases and to dry conditions.

Among valuable minor varieties is one more of American origin, Katahdin, which has been introduced to Australia recently and will probably be widely grown when stocks are multiplied.

Among varieties which have gone out of cultivation was one of outstanding merit, Brown's River or Circular Head. Sufficient material might still be found to establish stocks and test it again.

The suitability of American varieties to Australian climatic conditions is probably attributable to similarities between the American environment, where they were bred, and the Australian environment. However, none of the varieties grown here is ideally suited to its environment, and probably now or at some future time better varieties could be found to replace them.

At present the introduction and testing of new varieties is preformed haphazardly by State Agricultural Departments and private individuals. It could be done much more thoroughly by a centralised body whose function would be to introduce from abroad and test varieties with promising reputations. Such a body would need, as well as a field station and field laboratory in a potato-growing district, the close co-operation of the State Agricultural Departments. It would devolve on the latter to make final tests of suitability to particular districts and, if a variety were found suitable, to distribute it to farmers.

6. *Seed Certification Schemes.*—Certification Schemes are in operation in Tasmania, New South Wales, and Western Australia, and a scheme is being developed in Victoria. Their primary object is to protect potatoes against virus diseases, but they are also useful in maintaining the purity of varieties, in reducing the incidence of various fungal and bacterial diseases, and in sorting out vigorous and high yielding strains. All troubles which are wholly or in part tuber-borne, and are readily detected by inspection, are (or could be) reduced or eliminated under a Certification Scheme.

There are two steps in the production of certified seed: the maintenance of high quality foundation stocks, and the multiplication of seed stocks from them. Both are under the control of certification officers who inspect the growing crop and the tubers after they are dug, and provide official seals for bags of tubers that pass all inspections.

The actual maintenance of foundation stocks may, as in Tasmania, be performed by the Agricultural Department. It may be performed by growers. The multiplication of stocks is always performed by growers.

In the control of diseases, Certification must be supported by detailed information of the diseases concerned. This is particularly true of Virus Diseases.

Information as to the following is essential for the successful application of Certification Schemes to the elimination of Virus Diseases:—

(i) The types of virus which attack potatoes in the various localities.

(ii) The reactions of local varieties of potatoes to the different viruses.

(iii) The rate of transmission of viruses in the various localities.

(iv) Variation in the rate of transmission from year to year.

(v) Nature and habits of the agents which transmit the diseases.

(i) and (ii) are already being investigated by the Council for Scientific and Industrial Research in co-operation with State Agricultural Departments. There has been some work of a fragmentary nature on (iii) and there is a little information, but very little on (iv) and (v). As the rate of transmission depends on the number and effectiveness of the transmitting agents, a study of these agents (which are mainly aphides) is the next most important step in the control of virus disease in Australia. This should take the form of combined insect and virus disease surveys in the principal potato-growing districts.

Consideration should later be given to the possibility of eliminating or controlling the latent Mosaic type of virus.

7. *Potato Breeding.*—The discussion on varieties suggests the desirability of obtaining types adapted in the highest possible degree to the Australian environment. This is more likely to be accomplished by breeding than by introduction. Australia has not yet bred any outstanding varieties (unless the Snowflake, of which the origin is unknown, happens to be Australian), because there has been little concerted effort to do so. The only systematic breeding programme in operation is that conducted by the New South Wales Department of Agriculture.

Further breeding with ordinary commercial varieties appears unlikely to give substantially new types. Many of the best combinations of characters in the available genetic material already exist in established varieties. With the discovery by Russian botanists of many wild and cultivated varieties of potatoes in South America which contain comparatively enormous reservoirs of new and lost characters, an outlook of great promise has been opened to the potato breeder. Among the characters now available to him are:—

(i) Resistance to nearly all important virus diseases, to late blight, and to some other diseases and pests.

(ii) Resistance to drought.

(iii) Frost hardiness.

(iv) Very short or very long periods of tuber dormancy and exceedingly rapid maturity.

(v) Ability to produce maximum crops under short daylight conditions, i.e., during days when there is less than thirteen hours' full light. Most commercial varieties only produce their maximum yield under long daylight conditions.

(vi) Possibly greater yields than are at present obtainable and a wider range of tuber characteristics.

Any breeding programme with potatoes has to envisage continued effort for a period of at least 20 years, and the raising and testing of many thousands of seedlings. It involves:—

(a) The introduction, maintenance and testing of material for breeding.

(b) Study of the genetics of breeding material.

(c) The actual making of crosses and the raising of seedling types.

(d) The testing of these seedlings under various environmental conditions for their inherent characteristics.

Each of the four steps in breeding requires special forms of technical knowledge; and if breeding is to be done on a large scale, it needs a fairly wide range of equipment and personnel, and some division of function. For example, at a central station material might be kept and crosses made, and the seed from the crosses might be tested at a distant sub-station or even in another country. Provided the various centres are properly co-ordinated and directed, considerable advantages may be derived from a division of function, the principal one being the comparatively economical extension of the breeding programme to cover a wide range of characters. A programme of potato breeding for Australia is recommended for consideration. Two alternative policies might be considered:—

(i) A restricted and self-contained programme aiming at the solution of one or two problems of importance to Australia, e.g., the production of virus-resistant forms suited to local climatic conditions; or

(ii) One based on co-operation between Australia and the other parts of the British Empire, and covering a wider range of problems.

The former would require a personnel of one or two plant breeders and possibly another officer engaged in the introduction and testing of possible parent stocks, a permanent field station in a good potato-growing locality and co-operative arrangements with Commonwealth and State Departments for testing seedlings, etc.

The latter might mean the assumption of one or more of the functions set out under headings (a) to (d) above. A first step towards Empire-wide co-operation in potato breeding has been taken during the last two years in the support given by India and Australia to the recent small English expedition which collected potatoes in South America.

Note.—Of the varieties in the main potato-growing regions referred to on page 53, it should be mentioned that Carman in some districts is decreasing in acreage because of infection with virus diseases and the inferior Snowflake is taking its place. The relative proportions of the other varieties appear to be showing only season-to-season fluctuations.

Black Spot or Scab of Apples.

SERIOUS NEW OUTBREAKS RECORDED IN THE ALBANY AND MANJIMUP DISTRICTS.

W. P. CASS-SMITH, Plant Pathologist

Black Spot or Scab of apples, caused by the fungus *Venturia inaequalis* (Cke) Wint. or alternatively *Fusicladium dendriticum* (Wal) Fcl., has now been recorded from all States in the Commonwealth and it appears to be present to a greater or lesser degree in all countries where apples are grown.

Prior to 1930 the disease was unknown officially in Western Australia, but during that year the first authentic record of its appearance locally, was reported by Pittman (1) and further outbreaks were later reported by the same writer (2).

Wherever the disease occurs, it is regarded as a serious menace, for not only may the yield and quality of the crop be greatly reduced in seasons favourable for its development, but the costs incurred in applying control measures are also very considerable.

It is not to be wondered at, therefore, that many authorities consider it to be the most serious of all apple troubles, and all orchardists in this State who have, through no fault of their own, experienced its ravages, will completely agree with this opinion, as it applies here.

RECORDS OF THE DISEASE IN W.A. PRIOR TO THIS SEASON.

From April, 1930, until November, 1939, five outbreaks of the disease have occurred locally, and in only two cases can the outbreaks be attributed to infection which has spread from a common source, viz: —

Outbreak (1).—April 4th, 1930, on the property of Mr. J. W. Brearley of Manjimup, this being the first unquestionable record of the disease in W.A.

Outbreak (2).—April 29th, 1930, on Mr. Faulkner's property at the Porongorups (which is about 100 miles away from Manjimup).

Outbreak (3). February 5th, 1936, at Manjimup, on a property situated some five miles away from Mr. Brearley's on which the first outbreak occurred.

Outbreak (4).—March 7th, 1936, at Mt. Barker on Mr. G. Enright's property, which is approximately 100 miles from Manjimup. (Also traces of the disease were discovered on 11th June, 1937).

Outbreak (5).—November 19th, 1937, at Manjimup on a property adjoining that in which the third outbreak occurred in 1936.

It is worthy of note that in each instance immediately the presence of the disease was suspected, the Department was notified at once, either by the grower concerned or by another person on his behalf.

This public spirited action, which was made in each case with a full knowledge of the necessary obligations it would for the time being incur, was greatly appreciated both by the Department and all others interested in the welfare of the Apple Industry, for as the outbreaks were all discovered at an early stage, it enabled prompt action to be taken with the object of completely eradicating the disease and preventing its spread to other properties.

As a result of this timely knowledge, and the rigorous measures which were at once put into operation,* no signs of the disease have been discovered for nine years on the orchards where the first and second outbreaks occurred, nor for three years at the Mt. Barker orchard.

There is thus full justification for the claim that these outbreaks have been eradicated.

It is disappointing to record that more difficulty has been experienced in attempting to eradicate outbreaks 3 and 5, for until recently it was believed that these also had been successfully dealt with.

Outbreak 3 as previously reported in this Journal (2) was discovered in February, 1936, by the grower concerned, near the centre of his 15-acre orchard, and altogether some 40 or 50 trees, distributed over an area of 1½ acres, were found to be affected.

Immediate action was taken, and following the spring spraying schedule applied that year, no further evidence of the disease was noticed in the orchard despite constant efforts to find it, until this season. On the 19th November, 1937, however, a telegram was received from an adjoining grower, advising that Black Spot had been found in his orchard, and after verifying this report, further measures were put into operation on both properties for its eradication.

During the 1938-39 season, very careful inspections were made at intervals, in both orchards, and as not a single trace of the disease was found, it was believed that these, in common with previous outbreaks, had been wiped out.

OUTBREAKS DURING THE 1939-40 SEASON.

Recurrence of the Disease at Manjimup.

It is now obvious that Black Spot in a very slight form must have escaped detection on these properties during these inspections, for on November 15th, 1939, aided by very favourable weather conditions, a recurrence of the disease was reported by one of the growers concerned to Horticultural Instructor A. Flintoff, and during inspections made by this officer, it was found on both properties. Although since the outbreak originated in 1936 the disease had apparently spread to the orchard adjoining, this was the first definite record of its occurrence on both orchards at the one time.

Accompanied by the Acting Superintendent of Horticulture, Mr. H. R. Powell, the writer visited the district, when it was found that on the orchard where the first outbreak occurred in 1936, the disease was fairly slight, and restricted to "Cleopatra" and "Granny Smith's" varieties, only a few trees being badly affected. It was also noted that the affected area was confined to a portion of the orchard some distance from the area originally affected.

On the adjoining property the disease had recurred in the same part of the orchard, but at this stage it was not very well developed and it was visible mainly on the leaves. With the exception of some 15 rows of trees near the northern boundary, however, the disease was very general throughout the particular 15-acre block, and here also it was confined to the varieties "Cleopatra" and "Granny Smith's."

*These measures were originally planned by Mr. G. L. Sutton, Mr. G. W. Wickens and Mr. H. A. Pittman, who formerly occupied the positions of Director of Agriculture, Superintendent of Horticulture, and Plant Pathologist, respectively, in this Department.

New Outbreaks at Kalgan River and Jardee.

Knowledge of new outbreaks shortly came to hand, for on January 15th, 1940, Horticultural Instructor A. J. Gulvin, while assessing the yield of growers' crops (as required by the Apple and Pear Acquisition Scheme), discovered in an orchard at Kalgan River, near Albany, apple leaves and fruits which he thought were affected with Black Spot. Specimens were at once submitted to the Plant Pathologist, who confirmed his diagnosis.

The discovery of a second outbreak was also due to the alertness of an assessor, Mr. C. H. Button. On January 19th this officer, during the course of his duties, discovered the disease in a small orchard at Jardee.

Both districts were promptly visited by the Acting Superintendent of Horticulture, Mr. H. R. Powell, and the writer, and thorough inspections of the affected areas were made.

At the Kalgan River outbreak the disease was particularly severe on some 7 or 8 rows of "Cleopatra" apple trees, and altogether an area of approximately 2 acres in a 10-acre orchard was affected.

When stripping of the very badly diseased trees of this variety was carried out, practically all the fruit and many leaves showed lesions of the fungus. The disease appeared to have been active since quite early in the season, for fruit attacked at all stages of growth were noticed, and many of the lesions on both fruit and leaves were covered with the typical greenish brown spores of the summer or *Fusicladium* stage.

A few trees of "Yates" and "Granny Smith's" varieties were also badly attacked (the former on the leaves only), while symptoms of the disease were also noted on both leaves and fruit of "Dunns," "Jonathan" and "Delicious" in various other portions of the orchard. As this is the first record in this State of either leaf or fruit infection on "Delicious," which under Western Australian conditions appears to be very resistant to the disease, the severity of the outbreak can be appreciated.

Prior to this visit Horticultural Instructor Gulvin had hurriedly inspected neighbouring orchards and discovered that the disease had spread across the Kalgan River to an orchard some 300 or 400 yards away in a southerly direction.

The disease could only be found, however, on two "Granny Smith's" trees in a four-acre orchard, and these were situated at approximately the nearest point to the main outbreak.

Another larger block of trees, belonging to the same grower but some distance away, were apparently unaffected. Another neighbouring orchard some 200 to 300 yards away, but in a north-easterly direction, was subsequently inspected and the writer concentrated his attention on a single "Dunns" tree at the nearest point to the main outbreak. Eventually, after searching for fully twenty minutes, a single leaf showing what appeared to be the very early stages of the disease, was discovered. The symptoms at this stage, however, were not sufficiently clear-cut for accurate diagnosis, but subsequently after keeping the leaf alive under conditions suitable for the development of the fungus, Black Spot was positively identified.

All other neighbouring orchards were similarly inspected, but no further spread of the disease could be discovered in this district.

On visiting Jardee, it was found that the new outbreak was confined to a small commercial orchard, surrounded by a dense belt of virgin bush and situated approximately two miles away, as the crow flies, from the Manjimup orchards where the disease recurred earlier this season.

Here, the affected area was restricted to several rows of trees of the "Cleopatra" and "Dougherty" varieties which were severely attacked, but a few "Granny Smith's" and "Sturmer" trees had also suffered considerably. It is impossible to state, with any certainty, how the disease originated within this orchard, for being surrounded by dense timber and separated by a distance of at least two miles from the orchards where a recurrence of the disease broke out earlier in the season (and between which no personal contacts had been made), it seems improbable that it was due to wind borne infection. Furthermore, in previous outbreaks which were discovered at an early stage, the spread of the disease has not yet been recorded beyond the boundaries of adjacent properties. In view of all the circumstances, it seems more likely that the outbreak was due to an infection centre within the orchard itself.

MEASURES EMPLOYED IN AN ATTEMPT TO ERADICATE THE DISEASE.

Measures which it is fervently hoped will lead to the complete eradication of all outbreaks were immediately put into operation, and it is pleasing to record that these, in all cases, are being carried out most conscientiously by all growers concerned, with the fullest assistance of officers of the Department.

The following rigorous measures, based on those which have been successfully used for the eradication of previous outbreaks (modifications only being necessary, according to the nature and extent of the outbreak, and the time of its occurrence), are being enforced in one affected orchard and they will serve to show how seriously the Department regard the present outbreaks.

(1) All trees in the infected area and the ground beneath were sprayed forthwith with home-made Bordeaux mixture 6 : 6 : 40 strength, plus spreader, and as an added safeguard against the spread of the disease, a buffer area around the infected trees was also sprayed with home-made Bordeaux mixture 3 : 5 : 50 strength, plus a spreader. (Calcium caseinate at the rate of 1 lb. : 50 gallons of spray is preferred, but flour at the rate of 1 lb. : 50 gallons or skim milk, 1 gallon : 50 gallons are also suitable. See Leaflet 314.)

(2) All visibly infected fruit and leaves were stripped and destroyed; after the fruit of each variety is gathered as it becomes mature, the trees of each variety throughout the whole orchard and the ground beneath must be sprayed with home-made Bordeaux mixture 6 : 6 : 50 strength, plus spreader.

No apples may be sent away from the orchard either for sale or gift, without first obtaining permission from an inspector, and then only to destinations approved by him.

(3) Early in April a quick-growing cover crop of either oats, rye, or barley must be shallowly sown throughout the whole orchard, so that the diseased leaves will be prevented from blowing after leaf fall onto still uninfected parts of the same orchard or to other healthy orchards.

In August or early September (but at least a fortnight before spur burst commences) the cover crop must be deeply ploughed under, in one direction only, and subsequent cultivation must be delayed until approved and then limited to very light harrowing.*

*The Black Spot fungus persists in the affected leaves from one season to the next and during the winter months it forms fruiting bodies known as *Perithecia*. About the time that "spur burst" commences in the spring, the fruiting bodies burst and fungal spores or seeds are ejected from them into the air with considerable force. If the spores alight on the young leaves, blossoms, or fruits, they germinate in moisture and again bring about the disease. In order to prevent the disease reoccurring during the spring, the leaves must be buried deeply just before "spur burst" and left undisturbed until they have completely rotted. Cross ploughing or deep cultivation, if done too early, will bring the leaves up to the surface before the rotting is complete and before the fungal seeds contained therein are harmlessly dispersed under the soil, allowing infection to occur.

All areas beneath the trees which cannot be reached by the plough must be dug under by hand, this work to be so arranged that it is completed by the time the ploughing is finished.

In spring all apple trees in the orchard must be sprayed according to the following schedule:—

1. At "spur burst" when the tips of the young leaves are showing, home-made Bordeaux mixture 5 : 4 : 50, plus spreader.
2. At the "pinking" stage of blossoming when the majority of blossoms were showing pink, but before the petals had opened out, home-made Bordeau mixture 3:4:50, plus spreader.
3. At the "petal fall" stage, home-made Bordeaux mixture 2:5:50, plus spreader.

To assist the unfortunate growers with the carrying out of this onerous work, especially the destruction of all visibly infected fruit and leaves, officers of the Department have been stationed in each district almost continuously since January. As a result of their co-operation with the growers concerned the infection has in each case been very materially reduced.

ORIGINATION OF THE DISEASE IN W.A.

From the time the disease was first recorded in this State in 1930, the question of the source of origin of the outbreaks was a matter for conjecture.

On a number of occasions the importation of young apple trees from the Eastern States of Australia, where Black Spot is prevalent, was regarded with suspicion, and referring to the third outbreak of the disease which occurred at Manjimup in 1936, Pittman (2) states:—

"It is difficult to be sure of the manner in which the disease was introduced into Western Australia in 1930, or in the case of the present outbreak. In the present instance the disease apparently originated in a "Yates" apple tree growing adjacent to a group of young apple trees now in their second year, so that it is possible that the disease was introduced on an apple leaf still attached to one of the young trees or mixed up with the soil around the roots.

"In view of the fact that the majority of the young apple trees for planting in Western Australian orchards have always been obtained from Victoria, in which State the disease has long been serious and widespread, it is rather surprising that the apple-growing industry of this State has for so long remained free of this disease, which is held by many authorities to be, perhaps, the most serious of all apple troubles."

Since that time, however, overwhelming proof has come to hand that these suspicions were well founded.

On May 26th, 1937, Horticultural Adviser Powell discovered the disease on the leaves of young apple trees imported from Victoria, and carried over in an Albany nursery from the previous season. All apple trees in the nursery were forthwith destroyed and all trees from that consignment which had been forwarded to growers during the preceding season were closely inspected, both then and subsequently, with the result that no outbreaks have originated from them.

During the winter of 1937, in view of this experience, a close watch was kept on all consignments of apple trees imported from the Eastern States, and in a number of these consignments leaves affected with Apple Scab were discovered.

In this particular instance heavy autumn rains had apparently occurred, causing renewed leaf growth and as the trees had not been stripped of leaves before despatch the disease was in many cases readily apparent.

All nurserymen in whose consignments infected trees had been detected at the Western Australian ports of entry were forthwith given the option of either having these consignments destroyed or returned; altogether more than 11,000 trees were thus affected.

In order to prevent a repetition of this occurrence, which if undiscovered might have seriously jeopardised the future welfare of our apple industry, all Eastern States Departments of Agriculture, and nurserymen, were subsequently notified by the former Superintendent of Horticulture, Mr. G. W. Wickens, as follows:—

"As you are aware a large number of young apple trees sent forward from the Eastern States to Western Australia last season were refused permission to be distributed to growers owing to the fact that they were infected with Apple Scab, *Fusicladium dendriticum*, and to prevent that disease, which, fortunately, is very rare in Western Australia, from gaining a hold in this State it has been decided that all apple trees imported into Western Australia will, in future, before leaving the department's hands be dipped in Bordeaux mixture.

"As pear trees are possible carriers of Pear Scab, *Venturia pyrina*, they also will be subject to dipping upon arrival.

"The dipping in Bordeaux mixture will take place as a measure of safety, but should any trees be found infected with Scab, the supplying nurserymen will be given the option of having them destroyed, or returned to them. As the disease was last year found in every instance on the leaves of the trees, it is essential that all leaves should be removed before the trees leave the nursery."

It is not anticipated, therefore, that further outbreaks will originate from apple trees imported during and after the winter of 1937.

CLIMATIC CONDITIONS AND THE DEVELOPMENT OF THE DISEASE.

The development of the disease is favoured by fairly cool, moist weather during the growing season, and these conditions are most likely to occur in the Lower Great Southern and Lower South-West areas in districts such as Albany, and Manjimup. Although, should the disease ever become widespread, it may never be so serious here as in cool temperate regions such as Tasmania and New Zealand, nevertheless it can in favourable seasons, such as the present, and in the absence of control measures, cause tremendous losses. That the disease undoubtedly possesses the ability to persist under conditions extremely adverse for its survival is also certain, for it has been recorded here in four out of the five seasons, 1935-36 to 1939-40, and there is little doubt that during the fifth season it was present but escaped detection.

It must be patent therefore, to all growers how rapidly Black Spot of apples would become widespread if uncontrolled, and indeed there are good grounds for believing that the situation would then soon become similar to that which exists to-day in connection with the Pear Scab fungus to which it is closely related and which has similar climatic requirements.

It is fortunate that growers realise the necessity of immediately reporting the presence of Black Spot so that prompt steps may be taken to deal with the situation, for although the immediate costs of eradication may be high, they are infinitesimal compared with the constantly recurring costs of routine control measures, which might otherwise be necessary.

All apple growers, both commercial and non-commercial, should therefore familiarise themselves with the symptoms of the disease, especially those on the leaves, for at an early stage of infection or in seasons unfavourable for its full development, Black Spot may then be more apparent on the leaves than fruit.

SYMPTOMS OF THE DISEASE AND LIFE HISTORY.

(a) *Leaf Symptoms.*

Symptoms of Black Spot upon the leaves may be of two distinct types:—(1) more or less localised spots; (2) diffusely spreading, sooty or smudgy in appearance.

The first type takes the form when young of small more or less circular greenish-brown, or greyish-green spots with radiating ramifications of the fungus at the margins, and which under a hand lens, have the appearance of a very much branched or tree-like structure.

Occasionally the ramifications of the fungus radiating outwards from a central point of infection and easily visible to the naked eye may also be observed. (Plate I.)

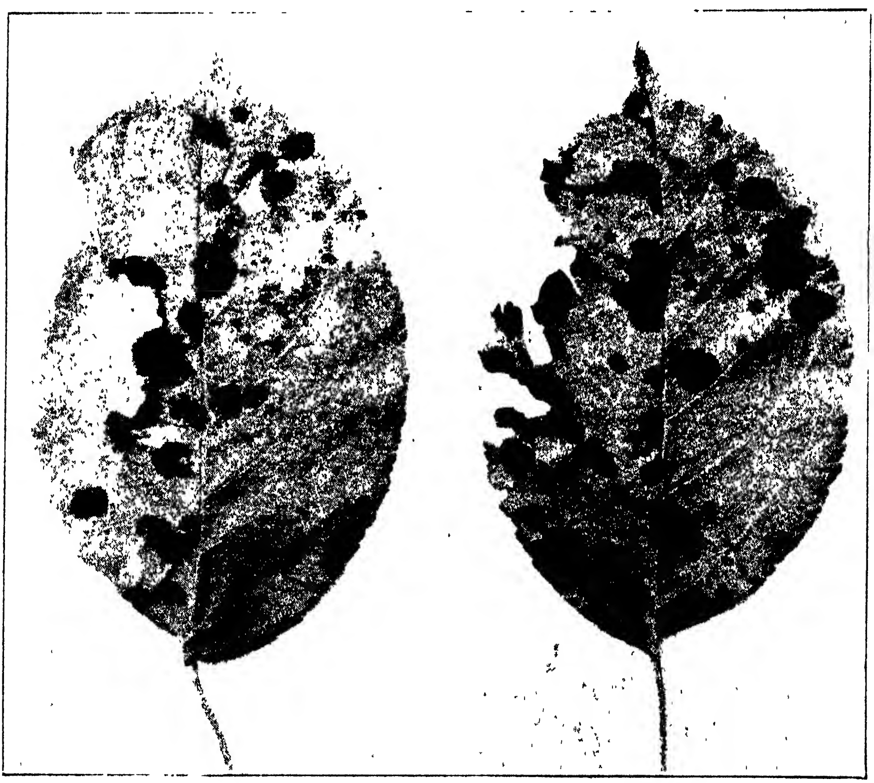

PLATE I.

"Black Spot" or "Scab" on apple leaves from Jardee, near Manjimup, January, 1940. Note the ramifications of the fungus radiating outwards from a central point of infection, in several lesions on leaf at left.

Later in the season, under favourable conditions, the scab spots may be covered with large numbers of spores, when they become olive green or almost black in appearance. If the spots are numerous, they may coalesce as they enlarge until ultimately nearly the whole leaf surface may be involved. (Plate II.) Frequently as the spots enlarge they become raised or blistered, the opposite surface becoming correspondingly depressed and the dark velvety surface then may become smoother, duller or sometimes shining and graphite like in colour, as the spores are rubbed, washed or blown away. Plate (III.)

PLATE II.

Apple leaves affected with "Black Spot" or "Scab" caused by the fungus *Venturia inaequalis* (Fusicladium dendriticum). Note on leaf at left numerous small localised lesions. On leaf at right the lesions along the main vein have enlarged and coalesced, ultimately almost the whole leaf surface may be involved. Near base of centre leaf two lesions have enlarged and their margins have just met.

In the second type of leaf infection, the fungus spreads diffusely, giving the leaf surface a sooty or smudgy appearance, and frequently the spread of the disease follows the direction of the main veins and occasionally the leaf stalk. (Plate IV.)

Both these types of leaf infection were noticeable in all outbreaks this year, but the localised spot form, later becoming blistered, was the more abundant; both the blistered and sooty or smudgy types were accompanied by considerable leaf distortion, Rarely were infections noted on lower leaf surfaces, where according to Cunningham (3) the earliest leaf infections occur.

(b) *Fruit Symptoms.*

"On the *fruits* the scab lesions first become obvious as small, brownish or black, irregular or circular spots without any break in the skin. With increase in the size of the lesions the *cuticle,* or transparent rubber-like coating over the first layer of cells, becomes ruptured, and the interior of the lesion then appears velvety and dark brown, or almost black, with an irregular and considerably frayed and torn, silvery-white, margin, which is the ruptured cuticle. This silvery-white and much lacerated

PLATE III.

"Black Spot" or "Scab" on apple leaves from Upper Kalgan, January, 1940. During enlargement the localised lesions frequently become upraised, presenting a blistered appearance, the opposite surface becoming correspondingly depressed. Lesions of this kind were abundantly present in all the affected orchards this season. Note distortion of the leaves at left and right. Lesions rather similar in appearance to the above caused by the closely related Pear Scab fungus are often seen on pear leaves in W.A.

cuticle can often be seen in the early stages with the naked eye (see plate 5) but it is, of course, much more readily distinguished with a hand lens. Under the lens the centres of newly-formed, smallish lesions, often have a mottled silvery-white and black appearance, due to the alternation of black patches of spores and pieces of ruptured cuticle. Many of the fruits infected in the early stages fall to the ground, but large numbers may persist on the trees. In such a case many of the infected apples will become badly distorted, owing to the more rapid rate of growth on the part of the healthy portions giving unsymmetrical development (see plate 6). With increase in the size of the fruits and the lesions, the centre parts of the diseased areas often become bare, and corky, and somewhat cracked or fissured, the edges of each lesion still, however, remaining infected and dark in colour, owing to the continual production of spores. It is this phase of the disease which has given rise to the common name of "apple scab." Once the centre of a fruit lesion has become hard and corky, any further increase in the growth of the still healthy portions of the fruit may lead to the development of very large and unsightly cracks in the diseased area. When fully-grown, or almost fully-grown fruits are

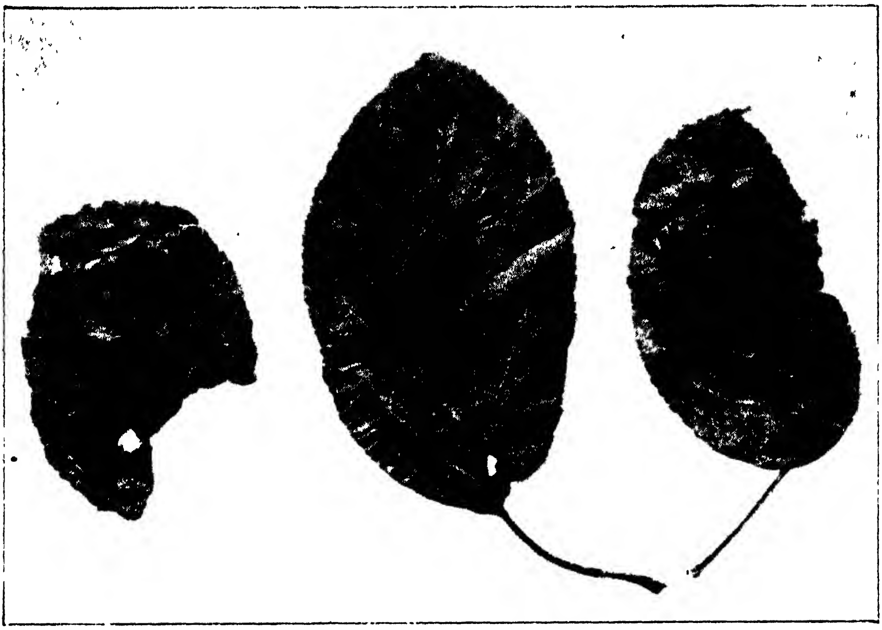

PLATE IV

"Black Spot" or "Scab" on apple leaves from Upper Kalgan, January, 1940 The lesions of the "Black Spot" fungus on the leaves are of two distinct types, (a) more or less localised in definite spots (see Plate II.); (b) diffusely spreading, having a sooty or smudgy appearance. In type (b) the fungus usually spreads in the direction of the main veins. Note on leaf at left, smudgy appearance caused by the diffuse spread of the fungus, on leaf at right the general spread of the disease along the main veins can be clearly seen. Note also the sooty appearance and severe leaf distortion On the centre leaf the fungus has spread upwards along the main vein, and downwards on to the leaf stalk.

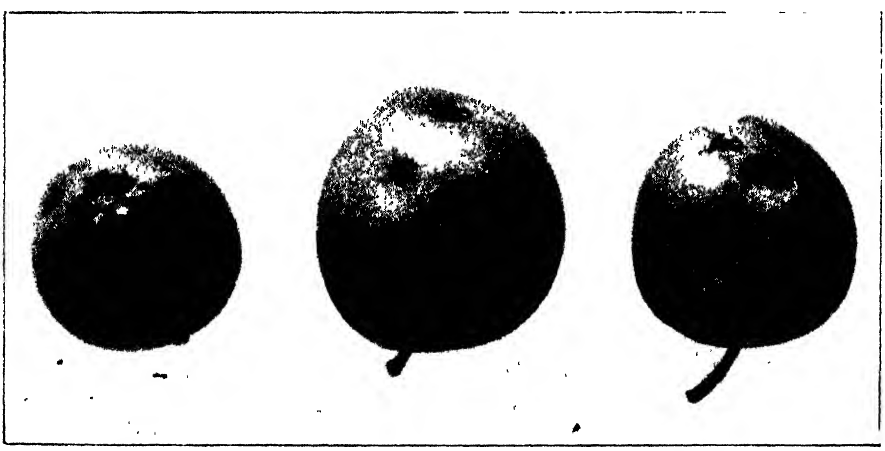

PLATE V.

"Cleopatra" apples from Jardee, January, 1940, affected with Black Spot. The apples were infected with the disease at different stages in their development. Apple at right infected at a fairly early stage shows considerable distortion. That on left infected at a much later stage shows so called "Pin Point" scab in which the fruit cuticle has just been ruptured by the developing fungus. Note also the silvery appearance of the ruptured cuticle around the margins of the lesions.

infected very late in the season, the lesions usually remain small, and the centres rarely become bare and corky. If apples recently affected with the scab fungus, or bearing *conidia* on their surfaces, are placed into cool or open storage, lesions may develop in the store (2).

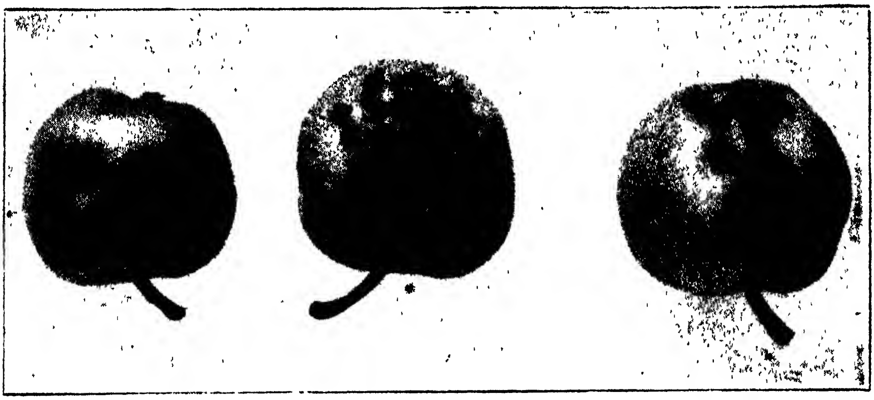

PLATE VI.

"Cleopatra" apples from Upper Kalgan, January, 1940. Affected with "Black Spot" or "Scab." Note the distortion of all fruits and the cracks in the centre apple.

(c) *Blossom Symptoms.*

The disease may also infect the blossoms causing lesions to appear on flower stalks and young fruits, petals or calyces.

Blossom infection considerably reduces the amount of fruit set and materially decreases the quality of much of the remainder.

(d) *Shoot Symptoms.*

Shoot infections have as yet not been noticed in Western Australia, but they are said to be confined to the bark of one-year old shoots. According to Heald (4). "Young lesions on the twigs are very similar in appearance to those on the fruits, showing the central spore surface borderd by the uplifted epidermis (skin). Later in the season the spores may disappear and the bark show a more scaly character, due to the peeling of the bark in flakes . . . The twig lesions may be few and scattered, and thus may be easily overlooked, or they may be so numerous as to coalesce and produce more extended affected areas" (2). The lesions on the shoots may play a part in carrying the disease over from season to season, where the winter conditions are mild, as they may, under such conditions, produce a fresh crop of *conidia* in the following spring.

VARIETIES AFFECTED.

Since the first outbreak of the disease in 1930, fruit infection has been noticed on the following main varieties, which are listed in what is considered to be the order of their susceptibility, the most susceptible being mentioned first.

The numbers in brackets refer to the number of times fruit infection has been noticed in different outbreaks of Black Spot:—Cleopatra (6), Granny Smith's (8), Yates (3), Dougherty (1), Dunns (2), Jonathan (2), Delicious (1).

RECOMMENDATIONS TO GROWERS IN THE VICINITY OF ANY INFECTED ORCHARD.

Prior to this season, outbreaks of the disease have never been discovered at one time or more than one orchard in each of two districts, whereas at present three outbreaks are known to exist both in the Upper Kalgan and Manjimup areas.

The apple growers in these two districts are thus confronted with a very serious situation which will require every effort on the part of all concerned if the disease is to be prevented from gaining a firm hold.

Those who already have the disease within their orchards *are* making every effort and with the aid of this Department, they are carrying out the prescribed measures for eradication faithfully and to the best of their ability. In order to make doubly sure that traces of the disease have not escaped the notice of inspectors on other orchards (and here the reader is reminded of the difficulty detection may at times present), all growers in the vicinity of these outbreaks, the locations of which are known to all concerned, are urged to carry out additional inspections and to be constantly on the watch for symptoms of the disease on leaves and fruit.

Furthermore, to guard against the introduction into other orchards of diseased leaves, which may be blown away before the cover crop has grown sufficiently to entangle them, growers in the vicinity of any outbreak are advised to adopt the measures previously described in Section 3, page 59, and in addition to apply the "spur burst" and "pinking" sprays, plus spreaders, at the stipulated strengths. Although the costs of carrying out these treatments will be substantial, *they only represent the minimum expenditure which would be required annually should the disease become widespread.*

There is one reassuring aspect of the present serious situation from which all apple growers (with the exception of those concerned in the affected areas) may derive satisfaction; all commercial orchards have been inspected this season by crop assessors of whose alertness mention has already been made.

It is hoped and believed, therefore, in view of the fact that the season has been most favourable for the development and the detection of the fungus that in commercial apple orchards all infection centres which at present exist have been discovered.

If the disease can be wiped out in these two districts, and this is by no means an impossible task, the growers in these areas will do themselves great service, and in so doing will earn the gratitude of all who have the welfare of the apple industry at heart.

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Oat, Wheat, and Barley Variety Trials in the Dairying Districts.

H. G. ELLIOTT, Agrostologist.

These trials have been conducted for a number of years by officers of the Dairy Branch. In the March, 1938, issue of this Journal a resume of the trials for the 1937-38 season was published. The object of the trials is as follows:—

1. To determine the variety of oats (if any) that give higher rates of yield per acre than the variety "Algerian."
2. To determine if barley or wheat gives greater yields than the oat varieties.

During the season 1938, the wheat varieties were deleted from the trials, as the results for a number of years prior to that season showed that the wheat varieties did not give yields in any way comparable with the oat varieties.

Fertiliser.— In every case one bag or 180 lbs. of superphosphate was applied per acre. The rate of seeding was 2 bushels per acre for oats and 1⅓ bushels per acre for wheat and barley.

Method.—Each variety was sown in plots of ½ an acre and in triplicate.

The following Table 1 gives the results of the three trials conducted during the 1939 season, and one which was conducted during the 1938 season and not included in the previous report.

TABLE 1.

Trial.	Algerian.	Wongan.	Burt's Early.	Mulga.	Barley (Atlas).
J. A. Lynam, Bridgetown—					
Tons per acre	1·73	1·58	1·50	1·47	1·41
Yield (per cent.)	100	91·30	86·20	84·30	81·00
E. W. Strike, Brookhampton—					
Tons per acre	3·32	2·75	2·44	3·24	2·67
Yield (per cent.)	100	82·83	73·50	97·60	80·42
Research Station, Denmark—					
Tons per acre	2·84	2·46	2·62	2·82	1·46
Yield (per cent.)	100	86·62	92·43	99·47	51·40
Research Station, Denmark (1938)—					
Tons per acre	1·42	1·01	1·30	1·35	0·84
Yield (per cent.)	100	71·12	91·90	95·07	58·80

(Hay yields estimated.)

J. A. Lynam, Bridgetown.—Information supplied by A. M. Tindale, Dairy Instructor. The varieties were sown on the 3rd July, 1939, on well drained red loam, which was originally timbered with jarrah and red gum. The land was disc plowed during early June, the oats drilled in and after drilling, harrowed. Oats were grown on this piece of land during the previous season.

E. W. Strike, Brookhampton.—Information supplied by A. M. Tindale, Dairy Instructor. The plots were sown on the 12th July, 1939, on red loam which was originally timbered with jarrah and red gum. For four years prior to the oats being planted the land had been under pasture which consisted mainly of subterranean clover. The land was plowed with a two-furrow mouldboard plow in the last week of May, the oats being drilled in and harrowed after.

Denmark Research Station.—The Plots were sown during the first week of May on light gravelly to sandy loam. The land, prior to the oat crop, carried the previous season a crop of Tick beans and prior to that had been under pasture for four years. The land was plowed with a disc plow and the oats broadcasted and harrowed in.

The average yield for all varieties for the three seasons is shown in the following Table 2.

TABLE 2.

Variety.	No. of Trials.	Hay.	Yield.
Oats—		tons per acre.	%
Algerian	11	2·33	100
Wongan	11	1·95	83·69
Burt's Early	11	1·98	85·00
Mulga	10	2·12	91·00
Barley—			
Atlas	6	2·30	98·71

It is anticipated that these trials will be conducted again during the coming season.

Pasture Development.

H. G. ELLIOTT, Agrostologist.

The fifth year's Report on the Rotational Grazing Demonstration under Irrigated conditions, being conducted on the property farmed by Mr. D. Moore and owned by the late Mr. A. E. Jackson, Roelands, is now available. This demonstration, along with those on the properties of Messrs. J. Neil and C. H. Henning, of Waroona and Hamel, respectively, has been conducted as a co-operative project by the State Committee of the Australian Dairy Produce Board Pasture Improvement Committee (W.A.) and the Field Staff of the Department of Agriculture*.

During the last five years the Australian Dairy Council has made available funds for the conducting of a number of experiments designed to increase and improve pasture production in Western Australia. The Dairy Council has now been merged with the Australian Dairy Produce Board Pasture Improvement Committee, which body has continued the work previously started, and has made increased funds available for further investigations. All the experimental work is controlled by the Western Australian Pasture Improvement Committee, working in close co-operation with the Department of Agriculture.

The initial objects of the demonstration were concluded last year, these being as follows:—

1. The collection of data regarding the carrying capacity of small areas.
2. The collection of information as to whether it would be more profitable to establish a permanent pasture with a cover crop than to sow Perennial pasture species alone.
3. The obtaining of the monthly yield of green material per acre.

*A resume of the first four years' operations have been published in the March, 1936, 1937, 1938 and June 1939 issues of this Journal.

4. The collection of botanical data to show the change in botanical composition due to rotational grazing under irrigated conditions.

The main object of the experiment during last season and this coming season is to obtain the following information:—

To test the effect of varying the time between waterings during the irrigation season, the information being obtained by means of grazing and yields. All information with reference to type of soil, seed mixtures used, fertiliser applied, initial cultivation, cover crops and irrigation have been given in detail for each field in the previous reports. The following details give further results of the experiment for the year ending 31st December, 1939:—

***Fertiliser*:—The rate of application of fertiliser for the fifth year (1939), was slightly higher than that of the fourth year, being 6 cwts. per acre, applied in three applications, the main application of 3 cwts. being given in the autumn. Table 1 gives the rate of application of fertiliser for the five years:—**

TABLE 1.

Year.	Fertiliser—lb. per acre.		
	Superphosphate.	Sulphate of Ammonia.	Lime.
1935	904	218	...
1936	374	8	448
1937	600	...	...
1938	560	...	...
1939	672	...	...

From the above Table it will be seen that the highest rate of application was given during the initial year of establishment. In this year some 904 lbs. super and 218 lbs. sulphate of ammonia were applied. During 1936 only 28 lbs. sulphate of ammonia were applied, and since that date no further applications of nitrogenous fertiliser have been given. Agricultural lime was applied only in 1936 over half of each field at the rate of 4 cwts. per annum. No effect from this application has been noticed to date. In no instance has potassic fertiliser been used. The basis of application of fertiliser during the last two years has been derived from fertiliser experiments which have been conducted under irrigated conditions on other properties. Here indications show that at least 6 cwts. are required per annum, the heavier rate of application being given in the autumn. In these experiments indications show that very little effect was obtained under irrigated conditions from the spring application of superphosphate. However, there are factors to show that summer applications, given just prior to irrigation, are profitable. Here it is recommended that at least 1 cwt. be given prior to watering, either in the months of December, January, February or March. It is possible that the December and March applications will be the most profitable.

***Renovation*:—A second renovation was carried out on all the fields during June of 1939. The first renovation was carried out in the middle of July, 1938. In both instances, all plots received a severe surface renovation with a rotary type of renovator known as, the "Sun-prong." Following the double renovation pasture blade type of harrows were used with half-chain harrows following the blade harrows. The effect of this second severe renovation was shown in the yield and grazing obtained from the area following the operations. It is considered that no surface renovation will be required over the area for at least another**

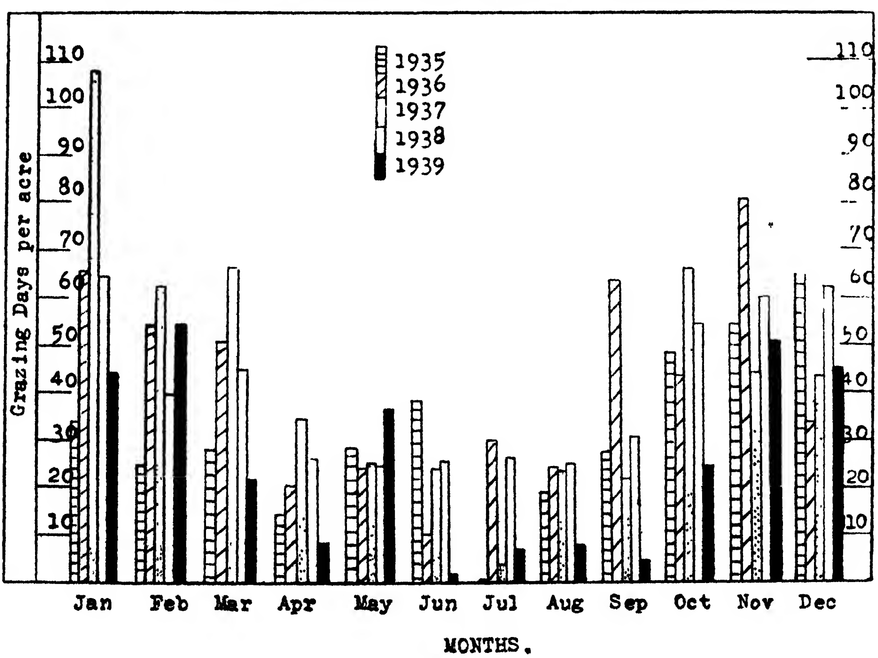
3-4 years. The necessity for the use of chain and blade harrows is obvious on small areas which are being grazed heavily. This operation is required to assist in breaking up animal droppings and spreading them sufficiently to obviate rank patches and growth, which normally occur wherever animal droppings are present on the pasture. During July, 1938, all the irrigation furrows were cleaned out with a modified type of "Sun-buster" plow. This operation was necessary to facilitate watering during the summer months. The complete area was topped twice with a mower during the summer to assist in preventing seed production of the paspalum, also to assist in controlling the spread of Ergot.

Weeds:—The control of rushes and Rats' Tails (*Sporobolus indicus*) was carried out during the year. It was found necessary to hand grub sections where these weeds occurred in quantity. Fairly good control has now been obtained.

Irrigation:—As mentioned in the last report in the June 1939 issue of this Journal, the system of irrigation has been altered to enable the Irrigation Officers to carry out a Time of Watering experiment. It is anticipated that the final information from this experiment will be available by the end of June. The following information gives in detail the method which has been adopted by the Officers of the Irrigation Branch for watering the individual paddocks. For the purpose of the work a water requirement of 1¼ inches per week has been adopted tentatively. On this basis Field No. 3 is watered at intervals of two weeks, Fields Nos. 2 and 4 at intervals of three weeks, and Fields Nos. 1 and 5 at intervals of four weeks, receiving respectively 2¾ inches, four inches and 5¼ inches of water per irrigation, the water being measured by a series of guages installed for this purpose.

Grazing:—The following Graph 1 gives the average monthly grazing days (8 hours) per acre obtained from the area for the years 1935-1939 inclusive.

Graph 1 - Average Monthly Grazing Days (8 hours) per acre.



From the above Graph it will be seen that the monthly production in grazing days per acre for the five fields was 25.6. This is very much lower than that of the previous years—1938, 40 grazing days per acre; 1937, 42.2 and 1936, 41.3. The months in which the greatest reductions took place are those of March, April, June to October inclusive. It is difficult to explain why a reduction in grazing took place during March and April. The reduction of grazing during the period June to October is due mainly to two factors:—

1. Excessive grazing during May.
2. Effects of severe renovation.

The beneficial effects of this renovation will be more noticeable during the coming season. Another factor which possibly contributed to the low production during these months was the effect of the watering programme on Plot 3. This gave a much lower grazing than the other plots for the year. Seasonal conditions also played an important part during the spring months on production. The month of September, during 1939, was the driest September on record for many years. Consequently all pasture suffered during this period and during the following month. The usual high flush did not occur. Irrigation commenced early in November, consequently, the production for November and December is equal to that which was obtained during the previous years. The total grazing obtained from all fields averaged 307.3 grazing days per acre per annum. This of course, is much lower than that obtained during the previous years, the average for 1938 being 480.5. Owing to the reduction in grazing obtained during the month of January, a slight increase was obtained for February. The amount of grazing obtained during February, however, was not much above the average of previous years. The previous three years' decline which occurred in feed through February grazing was followed by an increase during March. This, however, was not the case during the last season. Under irrigated conditions, the months April to August inclusive are definitely the lowest production periods of the year. Table 2 gives the full grazing production for the years 1935-1939 inclusive.

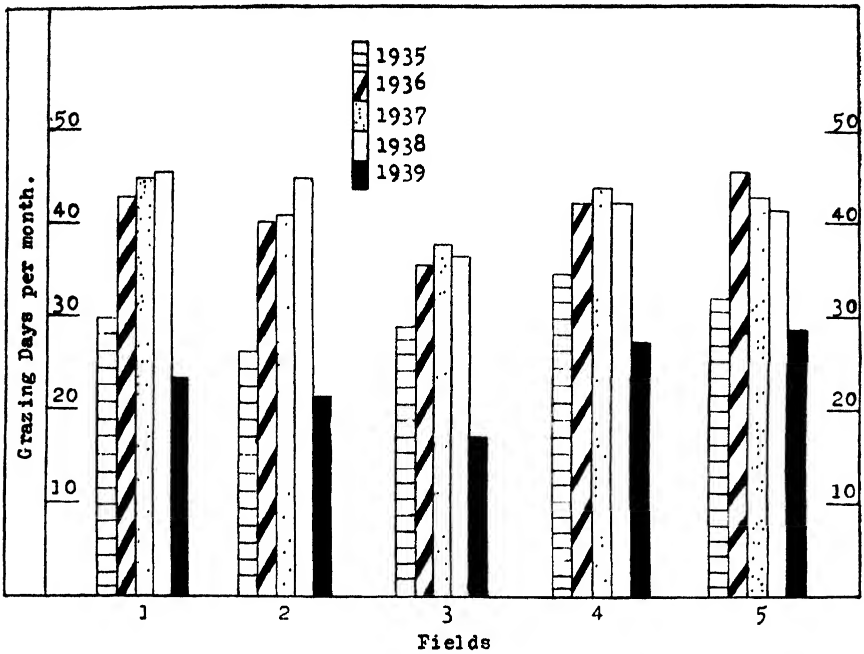
TABLE 2.

Year.	Grazing Hours.	Total Grazing Days.	Grazing Days per Acre.	Acres per Cow.
1935	38,373	4,796·6	371·2	0·97
1936	47,019	5,877·4	496 1	0·73
1937	52,200	6,525·0	506·6	0·72
1938	49,430	6,178·7	480·5	0·76
1939	30,001	3,750·0	290·7	1·25

From the above table it will be noted that the complete area has maintained a relatively high carrying capacity, and during the three years 1936-1938, a very high carrying capacity which was fairly constant, being equivalent to approximately one cow to ¾ acre. It will be noticed, however, that for the year 1939, the carrying capacity was only one cow to 1.25 acres.

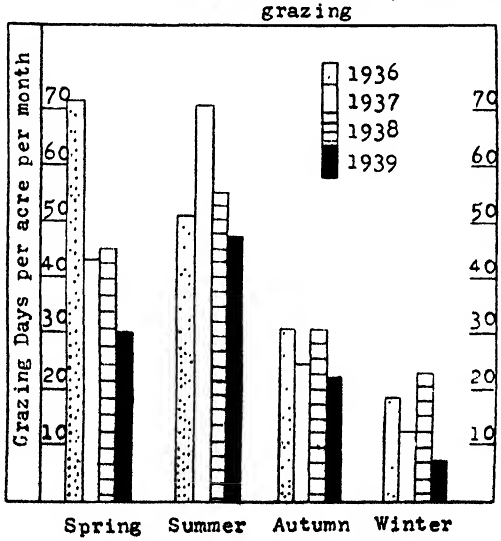
The following Graph 2 shows grazing days per acre obtained for the individual fields for the years 1935-39. The most marked annual variation occurs in Field 3. This, however, has been accentuated to some extent by the present system which has been adopted with reference to irrigation. This field, as explained in previous reports, originally had the heaviest cover crop, i.e., Japanese Millet. The effect of this cover crop in the earlier stages was most marked, more particularly with reference to the spread of White Clover and also the method in which couch grass

Graph 2 - Grazing Days (8 hours) per acre



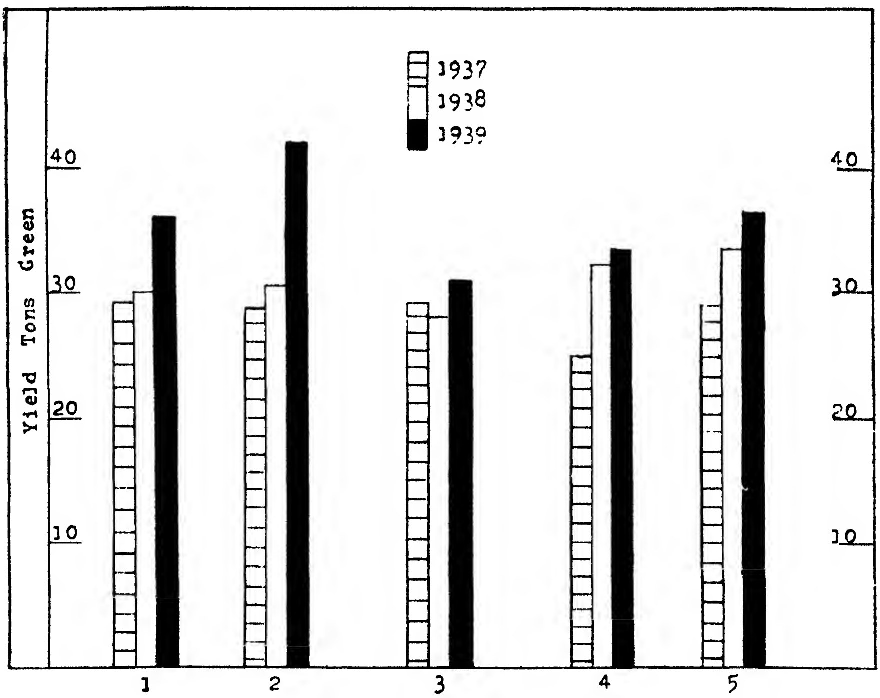
dominated sections of the area. It was very obvious from the results obtained in this field, that no beneficial effects were obtained in establishing permanent pasture under irrigated conditions with a heavy cover crop. Even the additional yield during the first year of this heavy cover crop did not bring about the highest production in grazing for the first year. No definite information, however, can be given with reference to the effect of the variation in watering practice being adopted over these fields, as the experiment is not yet completed.

Graph 3 - Showing three-monthly seasonal grazing



Graph 3 shows the monthly variation in grazing days which occurs during the three-monthly seasonal periods of the year. From this it will be noticed that the summer production for the last season was very similar to that obtained for the previous three years. The spring production, however, was considerably lower, the autumn production slightly lower and the winter production very much lower than the previous three years. The low production during the spring months has been explained earlier in this article, this being due to lack of rainfall during the month of September, also the residual effect of the severe renovation during the winter months. The excessive grazing during May and the renovation which took place during June, lowered the winter production. It will be noticed from Graph 5, however, that the three-monthly seasonal yield was very low during the winter months.

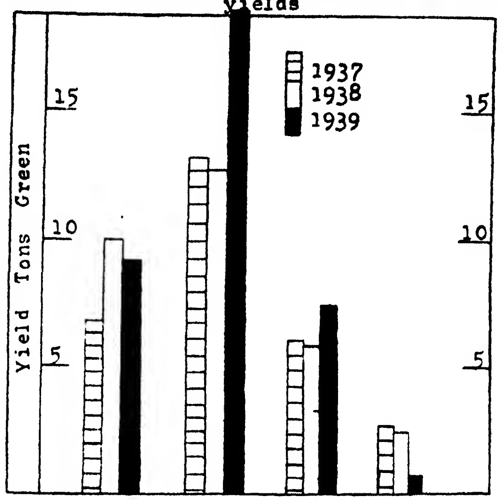
Graph 4 - Annual Production in tons, green, for the five Plots.



The above graph gives the annual production in tons of green material for the five fields for the years 1937-1939 inclusive. It will be noticed from this graph that the production of green material in tons for all fields was slightly higher than the previous year. This shows that the production of green material was high although the amount of grazing obtained for the year was much lower than the previous two years. The reason for this low grazing has been explained previously. The excessive grazing during May affected the amount of grazing obtained considerably, and also owing to the farmer being short of feed elsewhere during the winter and early spring months, a much quicker rotation of grazing occurred than was laid down for all fields. This, consequently, retarded the recovery of growth with a corresponding reduction in grazing days obtained. During the period 1937, the average production for the whole area was 28.1 tons per acre, in 1938, 30.5 tons per acre and for 1939, 36.1 tons per acre. This graph also

shows that for the three years in which yields of green material have been taken, Field 3 has given over the last two seasons a lower average of production than the other fields. This reduction in yields has occurred since the alteration in irrigation practice has taken place. When this rate of watering experiment has been completed, full information with reference to production and grazing will be related to the system of watering adopted.

Graph 5 - Showing three-monthly seasonal yields



Graph 5 gives the three-monthly seasonal yields in tons of green material for the three years 1937-1939 inclusive. It will be seen from this graph that the heaviest production occurs during the summer months, December-February. A much heavier yield of green material was obtained during the last summer than for the previous two summers. The spring production, however, showed very little variation, but the autumn production showed a slight increase over the previous two seasons. With the winter production there is a serious decline. Actually during the year 1937, 48.6% of the production occurred during the summer months, in 1938, 42.6% and in 1939, 52.3%. In the spring the production for 1938 showed a decided increase over 1937, being 33% of the total production. In 1939, however, it was 24.1%. It will be seen that for the period September to February inclusive, 1938, 75.6% of the production was obtained. In 1939, however, 76.4% was obtained. The winter production for 1937 was 7%, for 1938, 6% and for 1939 less than 4%. The 1939 figure showed a serious decline. This shows that these three months are undoubtedly the ones when the least amount of grazing can be expected. Consequently it is necessary for farmers to have ample conservation for the winter months and also for the other lean period, the autumn.

C. H. HENNING, Hamel.

Full particulars with reference to the establishment, cultivation, soil type, seeding, etc., of this experiment have been given in the March issue of the 1937 Journal. The objects of the experiment are:—

1. To determine the most suitable grass species in association with White Clover for the establishment of a permanent pasture under irrigated conditions on the soil type selected in this irrigation area.

2. The collection of information regarding the carrying capacity of pastures on small irrigated areas.
3. To determine the yields per acre of green material of various species under existing conditions.

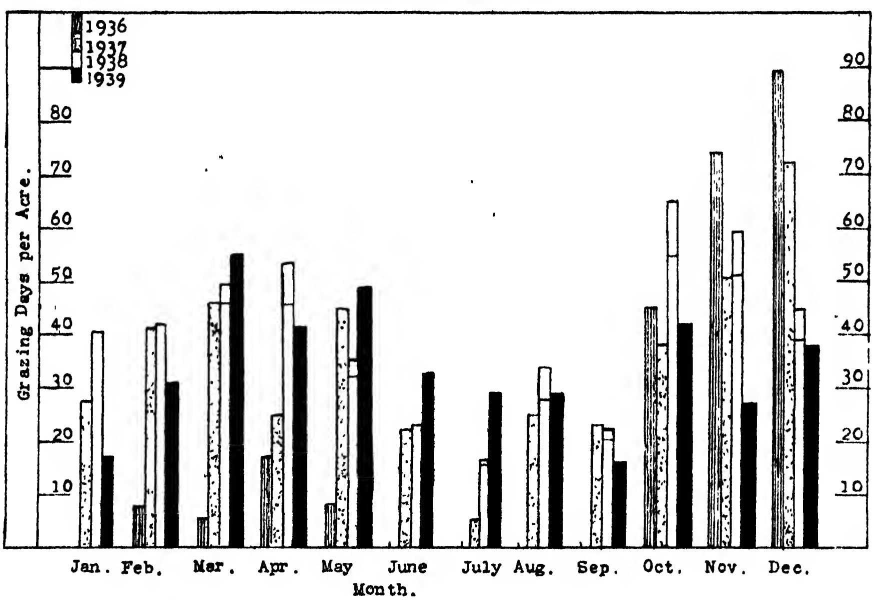
Irrigation:—During the past season four waterings were given, these being in January, February and November-December. The method of watering was similar to that used on the experiment being conducted at Roelands, i.e., the furrow system being adopted throughout.

Fertiliser:—Three fertiliser applications were given during the season. In each instance 2 cwts. were applied, the first prior to irrigation in February, the second in May and the third in September. During the previous season a total of 4 cwts. was applied in three applications.

Renovation:—It was considered that it would not be necessary to renovate the area during the last season, as it was sufficiently renovated during 1938. During the year, however, control of rushes was carried out.

Grazing:—The following Graph 6 shows the grazing days per acre obtained per month for each field for the past three years:—

Graph 6. Cow Grazing Days per Acre.



Note:—Graph showing grazing days (8 hours) per acre in the lower line of 1938 column gives grazing days per acre for all fields Nos. 1-5. Field No. 5 was not incorporated in this year's results.

From the above graph it will be seen that considerably more grazing was obtained for the months of March, May, June and July than that obtained for the previous three years. It is rather pleasing to note the increase in grazing which has taken place during the winter months. The production for the months September-December inclusive, however, showed a slight decrease, this being brought about by phenomenally dry conditions during September. Irrigation had to be carried out at an earlier date during last season than for any preceding year.

Table 3 gives the carrying capacity of the experiment for the four years, 1936-1939.

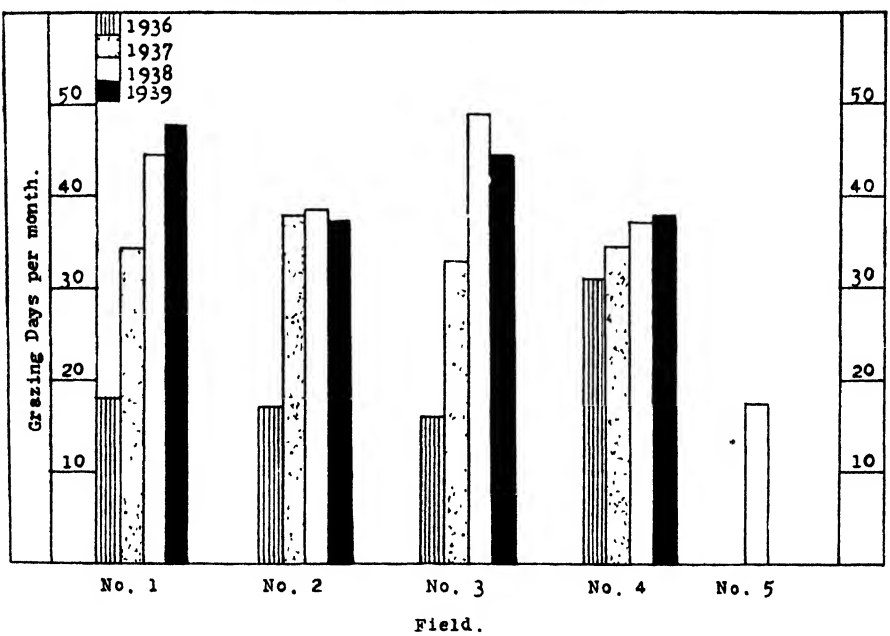
TABLE 3.

Year.	Grazing Hours.	Total Grazing Days.	Grazing Days per Acre.	Acres per Cow.
1936	16,504	2,063	250	1·46
1937	28,680	3,585	434·5	0·84
1938	32,957	3,990	499	0·73
1939	33,328	4,166	508	0·72

From the above Table it will be seen that the carrying capacity over the last three years has been very constant, being approximately 1 cow to 0.76 acre.

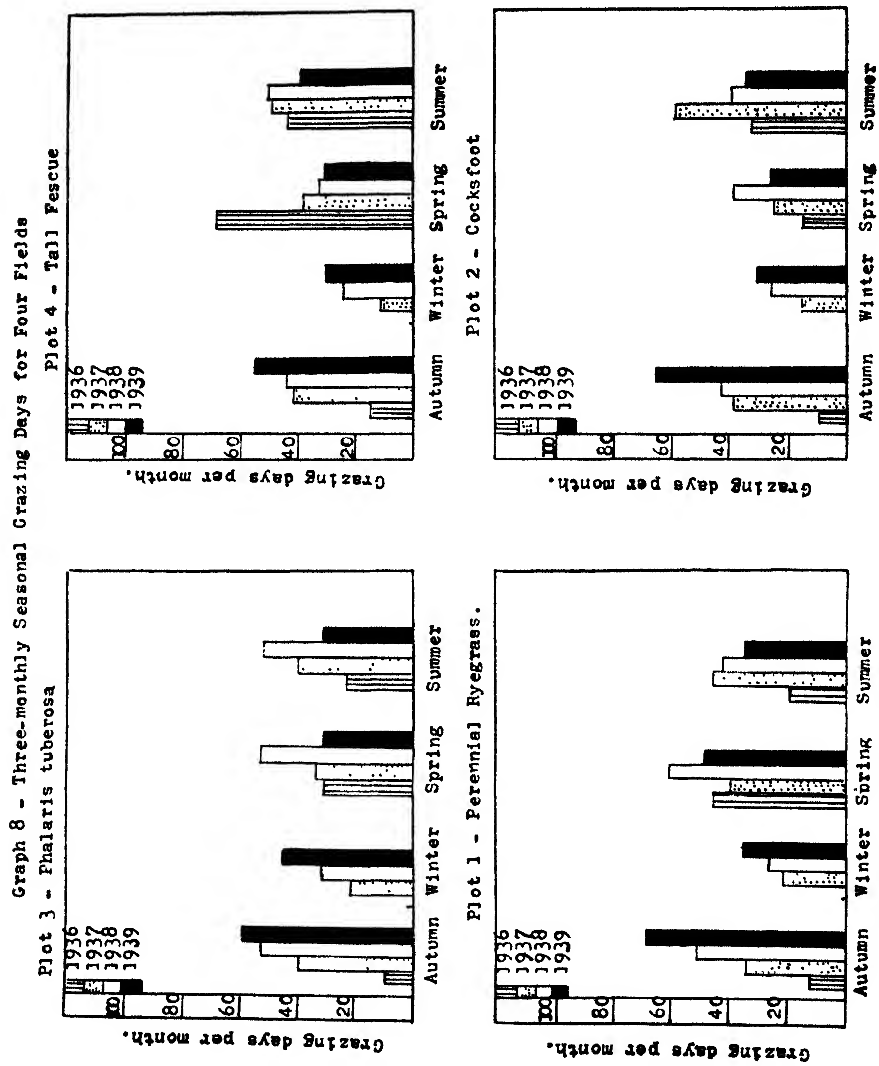
The following Graph 7 shows the average grazing days per month for the 12 months of each year 1936-1939 inclusive, for the various grass species in association with White Clover.

Graph 7. Cow Grazing Days (8 hours) per acre.



The average grazing days per month for Fields Nos. 1-4 for the year 1937, as shown in Graph 7, were 35, for 1938, 41.6 and for 1939, 42.2. It will be seen from this that there has been a slight increase during the last three years. It will be noted that Field No. 1 is still showing a steady increase in grazing days. Field No. 4 is still showing a slight increase over previous years, and Field No. 2 has remained relatively constant during the past 3 years. A slight decrease has occurred in Field No. 3 during the last season over the grazing obtained for 1938.

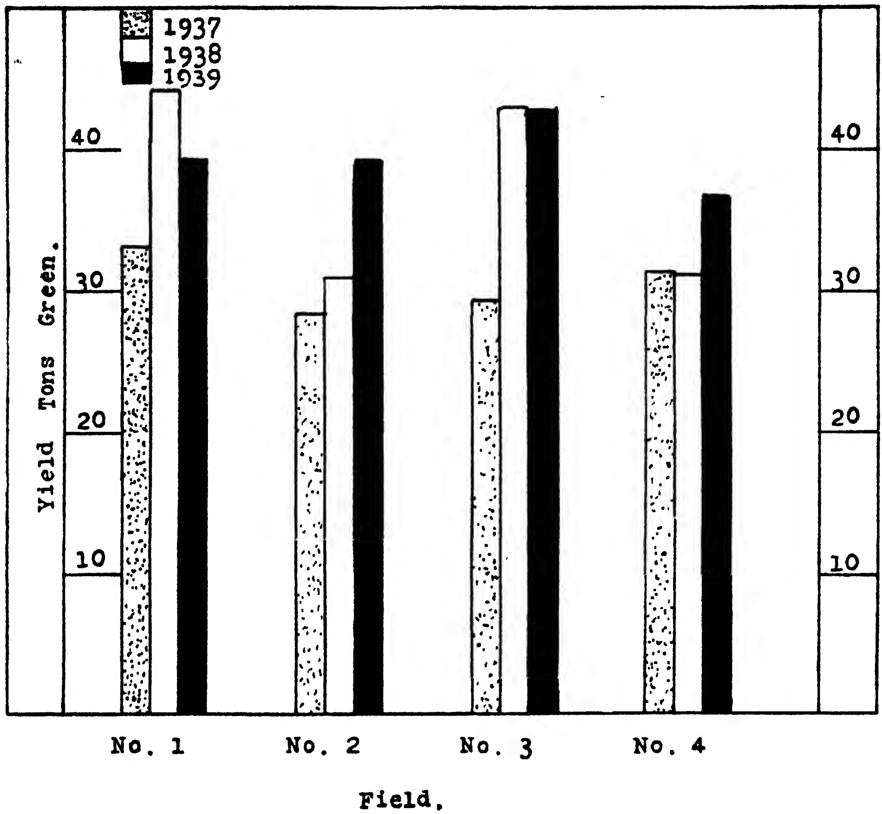
The following series of Graphs in Graph 8 show the quarterly grazing figures in each field for the four years 1936-1939 inclusive.



An examination of these graphs will show that the autumn production in every field is showing an increase over that of the previous years. Actually, there has been a steady increase in production during the autumn from every field for the years 1936-1939. Another interesting feature is the steady increase which is taking place in the grazing obtained during the winter months from all fields. It will be noticed from the series that Plot 3, *Phalaris tuberosa* and White Clover, is still giving the highest grazing figures for the winter period. In every case the spring production has declined from that of the previous year 1938, but was fairly constant as compared with that of the preceding years. The summer production had also declined from that of the preceding year. As the autumn and winter production are normally our two weakest periods for grazing, it is pleasing to note the increase which has been obtained for these periods.

Yields of Green Material:—The following Graph 9 gives the yields of Green Material which were obtained from each Field for the three years 1937-1939.

Graph 9. **Annual Production in Tons for the Four Fields.**



It will be seen from the above Graph that the production has increased for Fields Nos. 2 and 4, has remained constant in Field No. 3 and a slight reduction has occurred in Field No. 1. The average production for the year 1939 was 39.5 tons per acre, this being approximately 2 tons per acre in excess of that obtained for 1938, and 9 tons above that obtained during the year 1937. The production for the four fields in tons of green material for 1939 was relatively constant, being 39, 39, 43 and 37 tons per acre for Fields Nos. 1-4 respectively, the highest production being obtained in Field No. 3, *Phalaris tuberosa*.

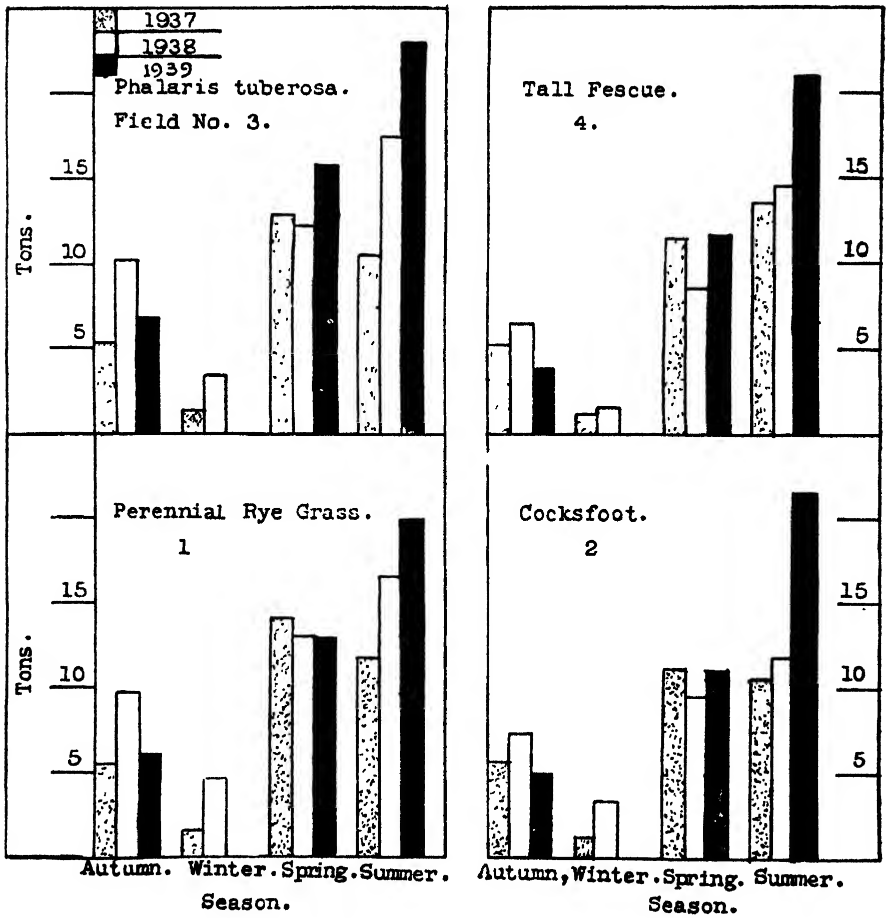
The production variations for the four fields for the period August-December inclusive for the four years, is given in the following Table 4.

TABLE 4.

Year.	1.	2.	3.	4.
	tons.	tons.	tons.	tons.
1936	12·7	11·1	10·6	8·1
1937	17·7	14·1	15·2	15·8
1938	23·9	17·9	22·9	15·8
1939	19·5	19·6	19·5	17·6

From the above Table it will be seen that the production from Fields Nos. 1, 2 and 3 were the same for the period August-December. There is a slight reduction in Field No. 4. The total production was slightly lower throughout that period of the year but Fields Nos. 2 and 4 showed a slight increase on the previous year.

Graph 10. Three-Monthly Seasonal Yields for the four Fields.



The following Table 5 gives the average three-monthly yields per acre for all plots for the four seasons of the year.

TABLE 5.

Year.	Autumn.	Winter.	Spring.	Summer.
	tons.	tons.	tons.	tons.
1937	5·3	1·3	12·6	11·3
1938	8·4	3·2	10·9	14·7
1939	5·5	...	13·0	21·5

It will be seen from the above Table that the production for autumn last season was approximately the same as for 1937, and slightly below that of 1938. The winter production, however, showed a relatively serious decline in yield of green material in tons per acre. The spring production showed a slight increase, whereas the summer production showed quite a considerable increase over the preceding years.

Graph 10 gives the three-monthly yield per acre for the four Fields for the three years.

The autumn production for all fields for 1939 showed a decrease over that obtained for the year 1938. In every case no winter production was obtained, although during the previous two seasons a light tonnage was recorded. In Field No. 3, however, there was a decided increase in production for the spring months. With the other three Fields the production was equivalent to that obtained during the previous three years. In every case the summer production had increased considerably. The absence of winter production was due mainly to the excessively wet conditions prevailing during these months, and no vast increase in the spring production was due to the dry September. The greater summer production was due to the increase in growth obtained following watering. While full observations will not be completed until the end of this season, some tentative conclusions appear legitimate. They are given at the end of this article.

J. NEIL, Waroona*.

The objects of the experiment are the same as those given for C. H. Henning, Hamel.

Fertiliser:—A total of 6 cwt. of superphosphate per acre was applied in three applications of 2 cwts. each during January, May and September, the January application being given just prior to watering. A similar rate of application was given during 1938. Four applications totalling 702 lbs. were given during 1937 and 900 lbs. plus 100 lbs. sulphate of ammonia was given during 1936.

Irrigation:—During the year the Fields were irrigated five times, January, February, March, November and December. The period between the waterings in November and December was 40 days and this length of time between application of watering is being reflected in the production obtained from the fields during the earlier part of this season. Prior to the December watering the complete area was showing the effects of drought conditions.

Renovation:—As the whole area was renovated with a Sun-prong during 1938, it was not deemed necessary that this operation be carried out again last season. However, the complete area was harrowed twice with a blade type of harrows. Topping was carried out only during January.

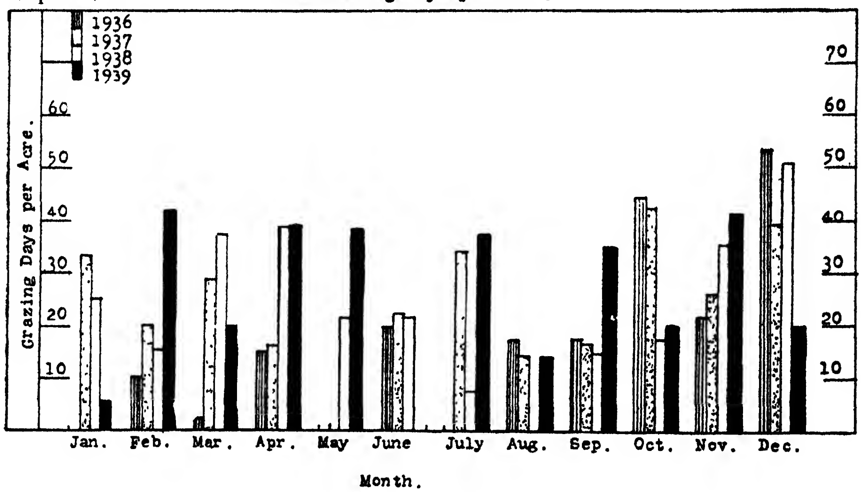
Grazing:—The following Graph 11 gives the grazing days obtained from each Field for the years 1936-1939 inclusive.

From this Graph it will be seen that the amount of grazing obtained during the months of January and March was lower than the preceding two years, but for February it was more than double that obtained during 1937 and 1938.

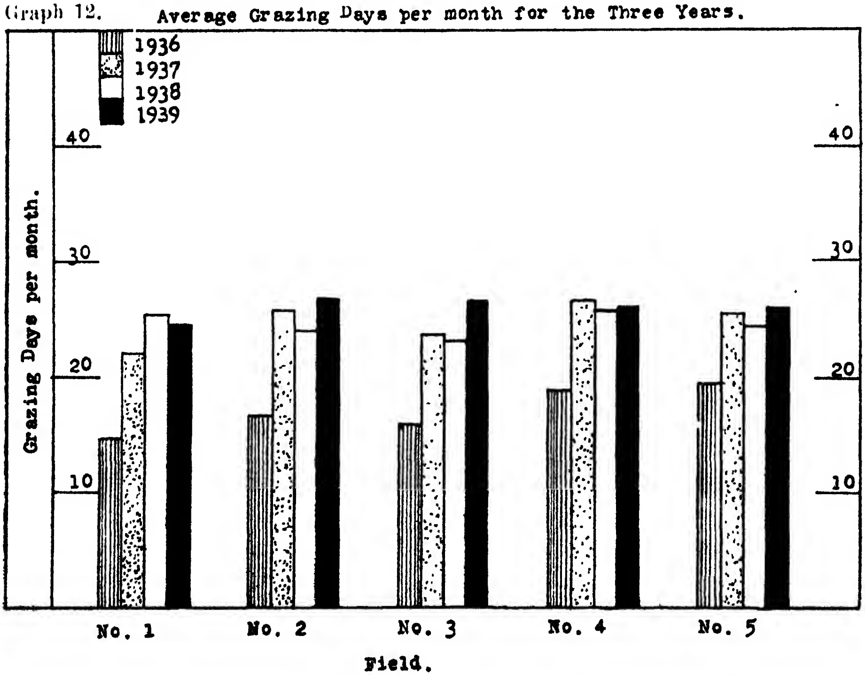
*Full particulars with reference to soil, cultivation, sowing, etc, have been supplied in the March, 1939, issue of this *Journal*.

The May and July production was also greater than previously, but no grazing was obtained for the month of June. The December production was about half that of the previous years.

Graph 11. Cow Grazing Days per Acre.



Graph 12. Average Grazing Days per month for the Three Years.



The following Table 6 gives the carrying capacity of the whole area for the four years 1936-1939.

TABLE 6.

Year.	Grazing Hours.	Total Grazing Days.	Grazing Days per Acre.	Cows per Acre.
1936	20,952	2,619	203	1·80
1937	30,3 4	3,798	294·4	1·24
193	29,891	3,736	285·8	1·28
1939	30,073	3,759	320	1·14

From this table it will be seen that the actual grazing obtained for the area was slightly better than for the three preceding years, being one cow to 1.14 acres. This was mainly due to the increased production obtained for the months February, May, July, September and November. The excessively wet conditions during June were probably the cause of the absence of grazing for that month. The effect of heavy grazing during November may have been instrumental in giving lower grazing figures for December.

The various grass species in association with White Clover gave an average grazing days per month for the years 1936-1939 as shown in the preceding Graph 12.

It will be seen from this graph that each species gave practically no variation in the grazing days per month for the four seasons, this again being due to some extent to the system of grazing adopted by the farmer each year.

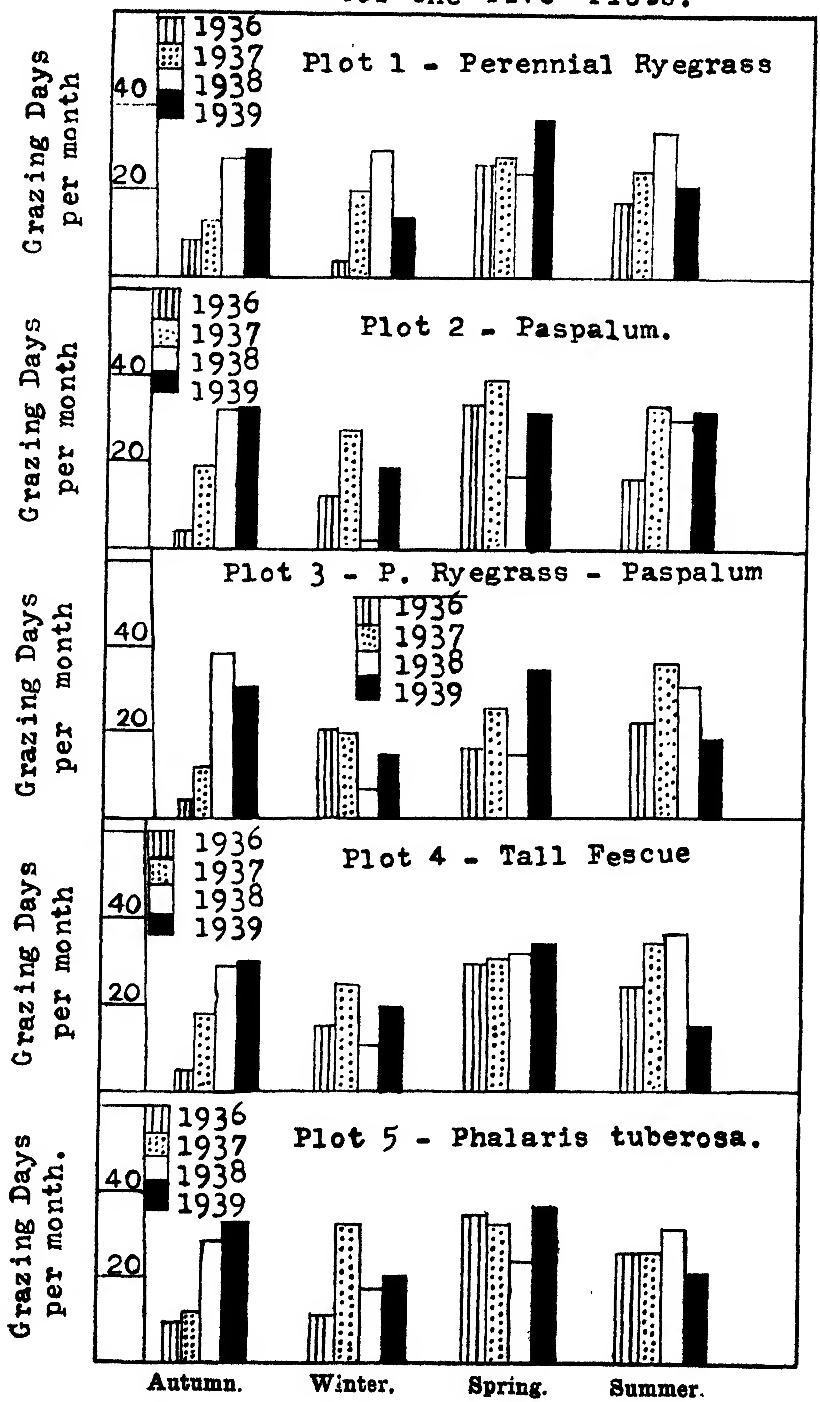
Graph 13 shows the three-monthly seasonal grazing days for the five Fields for the four years.

From the following series of graphs grouped in Graph 13 it will be seen that the spring production was slightly above the average obtained for the previous year. With Plots Nos. 1-3, however, a decided increase has taken place over the average production during the spring months for all years. An increase in the winter production occurred on all plots with the exception of Plot No. 1. Autumn production throughout remained fairly constant with that obtained for the previous season. There was a serious decline in the summer production on all plots, with the exception of Plot No. 2, this being Paspalum and White Clover association. The results throughout probably were affected to some extent by the system of grazing which was adopted by the farmer during the season. No definite information could be obtained during the past two seasons as far as grazing was concerned.

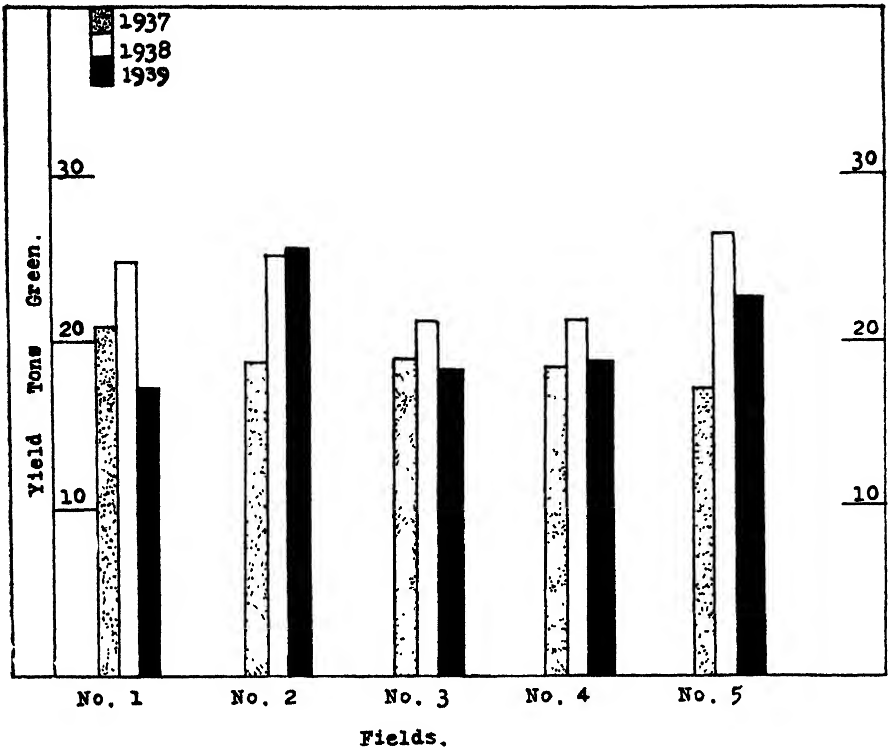
Yield of Green Material:—Graph 14 shows the yield of green material obtained per acre for the five Fields for the three years.

From this Graph it will be seen that Field No. 2 only gave the same yield as the previous year. All the other fields gave much lower yields. The average production per acre for all fields for 1939 was 20.4 tons per acre; for 1938 it was 23.9 tons, and for 1937, 18.9 tons.

Graph 13 Three-monthly Seasonal Grazing Days for the Five Plots.



Graph 14. **Annual Production in Tons for the Four Fields.**



The following Table 7 gives the production per acre for the three-monthly seasons of the years 1937-1939.

TABLE 7.

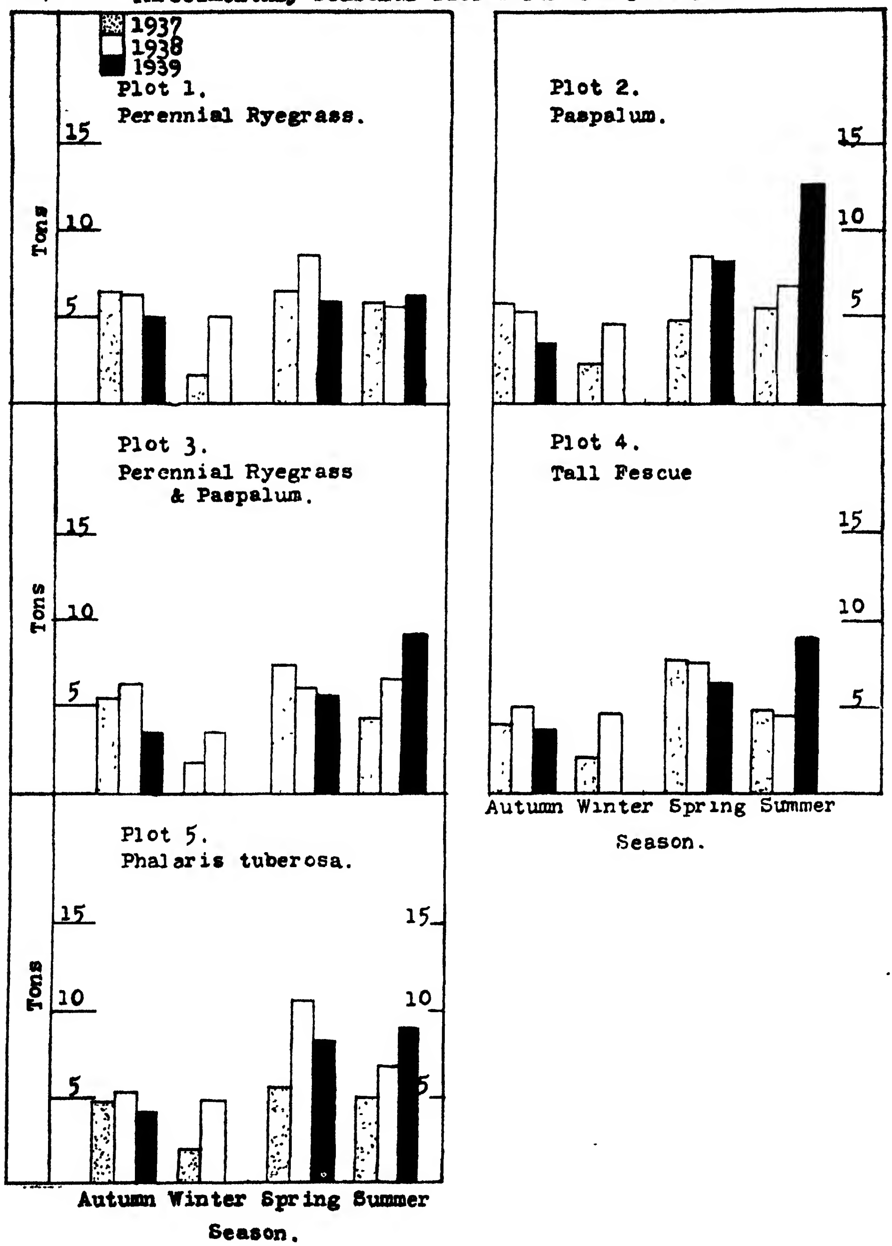
Year.	Autumn.	Winter.	Spring.	Summer.
	tons.	tons.	tons.	tons.
1936	...	...	...	...
1937	5·4	2·0	6·4	6·8
1938	5·4	4·5	8·2	5·8
1939	5·0	...	8·7	11·8

It will be seen from this table that the autumn production was practically the same as the previous years. The winter production, however, was negligible for 1939, whereas during the period 1937 it was 2 tons per acre, and 1938, 4.5 tons. The spring production was equivalent to that of 1938, but the summer production increased considerably, being 11.8 tons as against 6.8 tons for 1937 and 5.8 tons for 1938.

Graph 15 shows the three-monthly yields for the different seasons for each Field.

As will be seen from this graph, vastly increased production occurred during the summer on Plots Nos. 2 and 4, and a slight increase occurred on Plots Nos. 3 and 5, whereas Plot No 1 showed approximately the same production. The most outstanding feature was the lack of winter production for all Plots during 1939. Very little variation occurred in the production during the autumn and spring on all plots.

Graph 15. **Three-Monthly Seasonal Yields for the Five Fields.**



ACKNOWLEDGMENTS.

Grateful acknowledgment is made to Messrs. H. K. Gibsone and L. C. Lightfoot, Irrigation Officers, Roelands; Mr. T. Lutz, Agricultural Adviser, Waroona, and Mr. G. Brown, Field Technician at Head Office, for assisting in collecting the field information and compiling the figures given in this article.

Tentative Conclusions:—The results from the foregoing have shown that:—

1. Rapid growing cover crops are definitely detrimental to the initial establishment of White Clover, but not to paspalum. If Couch Grass (*Cynodon dactylon*) is present at the time of seeding, more particularly in the spring months, heavy cover crops will definitely assist the spread of this grass to the detriment of the sown pastures.

2. From the results obtained, rapid growing cover crops are not recommended when establishing permanent pastures under irrigation.

3. Rates of superphosphate up to 6 cwts. per acre are considered profitable, and at least 4-6 cwts. should be applied annually in 2 or 3 applications, the heavier rate (3-4 cwts. per acre) being applied in the autumn. Indications from the experiments being conducted show that summer applications of superphosphate just prior to irrigation are definitely profitable.

4. Superphosphate and sulphate of ammonia mixtures can only be recommended in the initial stages of establishment, more particularly at the time of planting.

5. Excessive and continuous grazing during the autumn and winter months seriously retard the production of the pasture.

6. It is not recommended that closer grazing periods than 20 days should be carried out. This applies to the spring and summer months. During the autumn and winter, however, longer periods between grazing are necessary.

7. The following seed mixtures can be recommended for the irrigation areas:

(a) New areas where no irrigated pasture existed previously—

Paspalum dilatatum	8 lbs. per acre.
New Zealand Certified White Clover	2 lbs. per acre.

(b) Where some irrigated pasture already existed—

Certified Perennial Ryegrass	4 lbs. per acre.
Paspalum dilatatum	4 lbs. per acre.
New Zealand Certified White Clover	2 lbs. per acre.
or	
Certified Perennial Ryegrass	6 lbs. per acre.
Certified Akaroa Cocksfoot	4 lbs. per acre.
New Zealand Certified White Clover	2 lbs. per acre.

8. *Phalaris tuberosa* and White Clover associate well under irrigated conditions, providing rotational grazing is efficiently managed. A period of at least 20 days in the flush season is required between grazings.

9. A mixture of Cocksfoot and White Clover is proving successful under existing conditions. It is now recommended that Cocksfoot could be added to Perennial Ryegrass and White Clover for the establishment of an irrigated pasture.

10. Perennial Ryegrass and Cocksfoot association with Paspalum and White Clover appears to assist in preventing matting of the pasture, thereby assisting in maintaining a relatively prolific sward.

11. Surface renovation is essential on Paspalum pastures to maintain an adequate proportion of clover growth. Chain and pasture harrows should be used annually during the winter months, to prevent rank growth appearing in patches.

Blackberry Eradication.

By H. TARLTON PHILLIPS.

INTRODUCTION.

The use of chemicals for weed killing purposes has received considerable prominence and attention during the last few years, and the article by Mr. H. Tarlton Phillipps details his experiences with chemicals, particularly sodium arsenite, for treating blackberries on his Balingup property.

It must be pointed out that the opinions expressed by Mr. Phillipps, in the course of his article, are his own personal opinions and do not necessarily represent those of the Weeds Committee.

Experiments mainly carried out in New Zealand and the Eastern States have shown that sodium chlorate and arsenical compounds including sodium arsenite and arsenic pentoxide are, in general, the most effective chemical weed killers. One decided disadvantage of arsenical preparations, is the danger of poisoning animals and this aspect has greatly reduced their use. Again sodium chlorate is inflammable, but certain proprietary lines have been manufactured to assist in overcoming this defect.

The Weeds Committee appreciates the fact that chemicals will play their part in blackberry control, particularly on roadsides, but stresses the possibilities of cultivation and pasture establishment associated with judicious management. Killing blackberries with sprays is naturally a costly process as not only must the cost of materials beincluded, but also that of plant and labour.

Experiments organised by the Weeds Committee at present in progress in the Bridgetown-Balingup district have been designed to compare the effects and costs of different concentrations of various chemicals and weed killing preparations, and also the results of certain cultural measures associated with pasture establishment. Included among the chemical applications is the sodium arsenite treatment found so effective by Mr. Phillipps and detailed in this article.

In an article on Blackberry Eradication, which has recently appeared in the Press, it is stated that extensive experiments in Victoria have shown that blackberries cannot be eradicated by spraying alone, and that success can only be attained where spraying is used in conjunction with cutting, cultivation, etc.

Systematic spraying on my Balingup property, extending over the last three years, has demonstrated, beyond any possibility of doubt, that blackberries can be eradicated by spraying, combined with burning, with absolute certainty, and at a small cost, even when they are growing under the most favourable conditions.

The explanation of this apparent anomaly is probably to be found in the fact that, in the blackberry infested districts of the Eastern States, there is, in most cases, a comparatively heavy rainfall during the Spring and Summer months. This would considerably increase spraying difficulties and also the vigor of the plants, during the growing season. Whether this be the case or not, it may be taken that, under conditions existing in the South-West corner of West Australia spraying is completely effective, provided that it is carried out systematically and at the proper times.

The country dealt with here consisted of about a mile of flats, along the Balingup Brook, infested with blackberries throughout, including some brambles about fifteen feet in height, which covered individually considerable areas, in addition to odd brambles growing on the hillsides and elsewhere.

The treatment applied consisted in cleaning up all titree and undergrowth along the brook, in order to give easy access to the brambles, which were then sprayed with a solution of Sodium Arsenite during the Spring and Summer months. In the case of the larger brambles, it was only found possible to spray around the margins. This, however, provided sufficient dead wood to enable a

fairly good burn to be obtained in the Autumn. It is most necessary, when starting on a bramble for the first time, to get it cleaned off level with the ground as soon as possible, in order to facilitate spraying and reduce the amount of solution required to a minimum.

In our spraying operations both Atlacide and Sodium Arsenite have been used, and we have demonstrated that blackberries can be completely destroyed by either. The arsenical solution appears to have given slightly better results. It is very cheap, and brambles burn fiercely after its application. It is also poisonous and must be used with reasonable care. The cost of Atlacide is prohibitive for extensive spraying, though it may, in some cases, be used advantageously in conjunction with the arsenic, as described later.

Sodium Arsenite solution is prepared by mixing 1 lb. of White Arsenic (Arsenious Oxide) with ½ lb. Caustic soda. The "flaked" variety of the latter is the most convenient. These amounts should be weighed and mixed dry. About an equal volume of water is then added and the mixture stirred. In about a minute it will boil violently, the solids being dissolved almost immediately. When solution is almost complete, further water may be added to make up to four gallons. If too much water be added at first, the temperature will not become sufficiently high to cause boiling and it will take longer to make up the solution.

This mixture, viz. 1 lb. Arsenic, ½ lb. Caustic Soda, and 4 gallons of water may be taken as the standard strength solution, as recommended by the Agricultural Department for spraying purposes, or for killing trees. We find that better results are obtained by using one quarter of this strength. In addition to reducing the spraying costs, and also the danger of poisoning stock, the time required to kill the blackberry is increased to about four or five days, allowing more time for the poison to be carried down to the roots. If blackberries are sprayed with this solution when the fruit is ripe, there is a definite risk that children might be poisoned as a result of eating the fruit within the next couple of days, before the plant begins to die.

Our spraying, throughout the whole of last season, was carried out with a barrel sprayer, containing 40 gallons, carried in a cart and fitted with 50 feet of ½ inch hose.

This length of hose is a great convenience and enables many bushes to be reached which otherwise would be out of range. A jet of the Spray Pistol type, or one with a trigger release, fitted with a three foot extension, is to be recommended, as it is essential that it should be possible to turn off the jet instantly to avoid spraying the grass. There should be no leaks from the jet, for the same reason, also the slight excess of Caustic Soda in the solution has a bad effect on the hands, and rubber gloves may be worn with advantage.

The solution recommended consists of 2½ lbs. Arsenic, 1¼ lb. Caustic Soda to 40 gallons of water. This gave excellent results provided that the work was done thoroughly with a good pressure, the rather weak solution increasing the time of dying and thus left more time for the poison to be carried down to the roots. At present prices the cost of materials is as follows:—1 cwt. arsenic, 45s.; ½ cwt. caustic soda, 29s. 7d.; Sales tax, 4s. 6d.; railage to Balingup, 150 miles, 8s. 3d. (No doubt exemption from sales tax could be obtained for this purpose). On these figures the cost of the spraying solution would work out at 1s. 11¼d. per 40 gallon cask.

The methods adopted by us during the last three years have varied somewhat in the light of experience and will no doubt be subject to further modification. Pending further information, the procedure recommended may be followed

with absolute certainty of success, provided that it is carried out in its entirety and spraying operations are carried out thoroughly and at the proper time.

When a start is being made on an untreated bramble, the method adopted will vary according to whether or not it is too large to spray completely. As already mentioned, where this is not possible, the margins should be sprayed towards the end of summer in order that a good burn may be obtained in Autumn. Where it is possible to spray the whole bramble, we have obtained very good results by spraying for the first time about the end of October. A fairly clean burn can then usually be obtained towards the end of November without burning the country. When the re-growth is about 1 foot or 18 inches in height, spray again. Repeat the process when the second re-growth is about the same height. Towards Autumn, there will probably be a third re-growth. This will not be strong, and if it be not allowed to develop too much, there will be sufficient dry Blackberry to enable a very clean burn to be obtained, which will destroy the third re-growth.

The ground will now remain virtually bare during the winter. By the following November a definitely weak re-growth will occur, but in most cases, anything from 50 per cent. to 75 per cent. of the original roots will be dead, and the growing plants will be separated by considerable spaces. These should be sprayed as in the previous year, and again burnt off at the end of the season, if possible. Probably they will be too far apart. In the third year the bramble will be virtually dead, though a little spotting may be necessary.

No general rule for spraying can be given, since individual brambles vary greatly in vitality. In some cases, one spraying will kill them, and in others it may take two or even three years. In no case should the re-growth ever be allowed to get more than 12 or 18 inches in height or to develop runners. It is useless to start on a bramble and to fail to spray at the correct time, since the roots soon recover their original vigour, if spraying is neglected.

It might, at first sight, appear that the above treatment is a full time job. In practice, after the first spraying and burn, the amount of time and solution required are surprisingly small and a very large area can be covered at a small cost, both as regards time and material.

Sodium arsenite is poisonous to stock, if sprayed on grass. With care, this risk can be reduced to a minimum. The writer has not had experience with sheep in this connection. Cattle do not appear to eat sprayed brambles, though it is wise to keep them away for a few days after spraying, while the brambles are dying. The risk with large brambles appears to be very small. There is however, a slight risk in the case of small plants a few inches across, growing in grass, since a considerable amount of spray must go on the grass surrounding them.

It has been shown that the amount of white arsenic necessary to kill a beast, varies from 225 to 700 grains. A solution of the strength recommended for blackberry spraying contains 1 oz. or 437 grains of arsenious oxide per gallon, and it will therefore be evident that it would be necessary for a large amount of sprayed grass to be eaten to produce lethal effects.

The writer recently sprayed 115 seedlings, from 6 inches to 12 inches across, growing in green grass about 6 inches in height on an area of 270 square yards, with the above solution. All this grass was eaten by several head of cattle a few days later, without any symptoms of poisoning being apparent. At the same time, poisoning might possibly occur in certain cases. Since only 75 grains of arsenious oxide are necessary to poison a sheep, the risk in that case might be greater. It will be noted that the figures given refer to white arsenic and not to

sodium arsenite, the toxic effects of which may be somewhat different. They will however, serve to give some idea as to the risk.

Large areas of badly infested country may be temporarily fenced off, where this can conveniently be done. It should also be borne in mind that, after one or more sprayings and a burn, the sprayed area remains bare, apart from any re-growth of blackberries. When this occurs, the area may be safely sprayed with arsenic, grassy margins and small isolated plants being subsequently done with Atlicide, which is not poisonous. We have found this procedure satisfactory. Spraying carried out on the lines laid down, will be found successful in all cases.

The blackberry grows mainly in temperate countries, being most troublesome where summer rains are experienced or where soils are naturally moist during the warm season.

The method of attack should be to spray, as far as possible, and, at all costs prevent it from seeding, which can easily be done by burning. At present practically the only agent in the distribution of the seed is the Silver Eye, which does not appear to travel any great distance from its source of food, and in consequence, to distribute the seed over any great area. If, at any time, the Starling and Sparrow, both of which are numerous in South Australia, should obtain a footing in this State, the blackberry within a year or two might become universal throughout the South-West. Let us therefore deal with it while it can be done easily, and before it is too late.

A curious and unexpected feature of this Arsenical Spray is that it does not appear to have any permanent ill-effect on the land. Areas of our flats, which, three years ago were so thickly covered with brambles that it was impossible to walk through them, are now densely coated with Paspalum, which attained an average height of about three feet last season, in spite of the land having been subject to numerous arsenical sprayings during the preceding two or three years. Paspalum and Kikuyu grass form an excellent insurance against re-infection with blackberries, which appear to be unable to establish themselves on land well covered by these grasses.

In conclusion I would again urge everybody to take the problem in hand, and at least, to prevent any further seeding. In our own case, the position appeared virtually hopeless, but in the space of three years we were able in practice to clear up half the property and get the remainder under complete control, with a very small expenditure of time and money and the certainty that, within a comparatively short time, the last blackberry on the property will have been finally destroyed.

Tubercle-Free Herds.

The following herds have been declared free from tuberculosis in accordance with the requirements of the Scheme for the certifying of herds tubercle-free, and unless otherwise declared the certificate remains in force until the date shown in respect of each herd:—

No.	Owner.	No. of Cattle Tested.	Date of Expiry.
			1940.
1	A. Groves, Toodyay and Wagerup	187	31st December.
2	School of Agriculture, Narrogin	38	do.

Fertilisers—Additional Registrations.

The last December issue of this Journal contains a list of the fertilisers registered for the current fertiliser year, together with the minimum percentages of the fertilising ingredients. Additional registrations, with the respective analyses, are shown in the following table :—

Name of Fertiliser.	Reg No.	Brand.	By whom Registered.	Nitrogen (N_2) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on rails at Perth.
				Nitrate.	Ammonia.	Blood and Bone	Bone-dust.	Water sol.	Citrate sol	Acid sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Nitrate of Soda	135	Champion	A. Hicks	16·0	...	...	...	...	...	...	...	...	...	‡16 0 0
Kainit	136	"Stork"	Westralian Farmers, Ltd.	...	...	...	...	...	...	...	...	...	14·0	*
Sulphate of Potash	137	do.	do. do.	...	...	...	...	...	...	...	...	48·6	...	*
Potash Manure Salts	138	do.	do. do.	...	...	...	...	...	...	...	...	...	30·0	*
Muriate of Potash	139	do.	do. do.	...	...	...	...	...	...	...	...	...	50·0	*
Phosphatic Guano	140	"Cormo"	M. F. Phillips	...	...	...	2·2	...	...	22·0	22·0	...	...	†5 2 6
Fish Fertiliser	141	do.	do. do.	...	...	5·0	...	...	...	8·0	8·0	...	...	†9 12 6
Batsos—The Complete Fertiliser	142	Batsos	Chemtek (W.A.)	...	...	...	1·0	1·25	1·0	1·75	4·0	...	...	*

* Price on application. † Price at Works. ‡ Price on Rail at Fremantle.

COMMONWEALTH OF AUSTRALIA.

Dissemination of Meteorological Information.

Under the restrictions imposed by the Censorship on the broadcasting and dissemination of weather information, it was necessary to devise a system whereby reports and forecasts could be made available to pastoralists and others for whom they are an economic necessity. Arrangements were effected at the Central Administration and at Divisional offices of the Commonwealth Meteorological Branch for the issue of district forecasts for country areas throughout each State to be furnished to all telegraphic offices at 12 noon daily. Although the restrictions have recently been lifted the service is still in force and interested parties desiring the forecasts for a district are advised to apply by telephone or reply-paid telegram to their local postmaster, or, if more convenient, to the Weather Bureau, Perth, Telephones Nos. B4599 or B4990. The information is also displayed on Post Office notice boards.

Butter: Its Composition and Deterioration.

H. H. KRETCHMAR, Dairy Bacteriologist.

SYNOPSIS.

In the following paper an attempt has been made to survey the present state of knowledge concerning the composition of butter and the course of its deterioration. It will not be possible to present the whole of this material in the present issue of the Journal; the paper will be completed in the next issue.

Because of their fairly general use in research work the first section discusses the present methods of grading butter. The difficulties of grading the material by the senses of taste and smell are explained and possible methods of more scientific value are considered.

Since salt and acidity affect the flavour of butter, the next two sections of the paper deal with this matter. As a logical deduction the writer shows that some of the experiments mentioned in the literature, and later quoted, are unsound because this aspect of the problem has been neglected; in other words, more than the one factor being specially studied has influenced the experiments, and these other factors, salt and acidity, have a definite influence upon flavour.

The influence of various controllable factors upon the deterioration of butter is next discussed. Data is quoted to show the effect of acidity upon keeping quality when the material is held in cold storage, and also when the material is held at room temperatures. The two sets of data, taken conjointly, indicate that the acidity for best keeping quality is independent of storage conditions. The acidity for optimum keeping quality is pH 6.7 — 6.9.

Data is quoted to show the effect of copper and iron impurities in accelerating the rate of decomposition. The probable influence of acidity in controlling the effect of these substances is mentioned.

The effect of the temperature of storage on the rate of deterioration is next considered. Data is quoted to show that when factors which cause decomposition are operating, small changes of temperature, even when such temperatures are low, caused marked increases in the rate of deterioration.

A section dealing with the gas content of butter shows that 100 gms. butter contains about 4-5 ccs. of gas. The writer has given a simple calculation to show that the greater part of this gas is not dissolved in the serum but is dispersed throughout the mass of the butter as small gas bubbles. Because of its fine state of division the gas presents a very large surface of contact with the butterfat, an ideal condition to cause oxidation of the fat when the gas contains oxygen. In the following section data is quoted to show that at 0°F. little oxygen is absorbed, but, at 32°F. oxygen is absorbed comparatively rapidly.

A section is devoted to the composition of butterfat. It is shown that the composition is variable, being influenced by the seasons and the feeding of the animals. A particularly important analytical constant of the fat is the iodine value, for this gives a measure of the percentage of unsaturated materials present, materials which are readily oxidised and which, because of their low melting-point cause softness of the butter. The Reichart-Meissl value is also of some importance as a measure of material influencing the hardness of fat, and is a measure of those substances which, upon hydrolysis, may give rise to substances having objectionable odours and flavours. The question of the odours of the lower fatty acids is discussed.

The problem of butterfat oxidation is considered from various aspects. In the first place the writer has noted that probably no experiments have been made on the oxidation of pure butterfat. When other materials are present with the glycerides, as is the case with the fat phase as usually obtained from butter, and more particularly when butter itself, or milk is being examined, some of these materials are oxidised, or partially oxidised, in preference to the glycerides. The course of the oxidation is probably different in butter to that in the separated fat phase, and quite likely differs at elevated and at low temperatures.

The nature of the oxidation change is indicated and the aromas and flavours of oxidation products considered. Many of the chief oxidation products have marked odours. The odour of rancidity is certainly not due to butyric acid but is perhaps due to heptylic aldehyde. The "oxidised flavour" of milk is probably due to a lecithin decomposition product.

Reference is made to the substance responsible for the development of the pink colour in the Kreis test for rancidity. The substance responsible for the odour of rancidity is not the same substance as causes the development of the colour in the Kreis test.

In the next section data is quoted to show the extent of the correlation between the analytical figures for the extent of fat oxidation and the fall in grade. The writer notes that deterioration of butter is not due to any one factor but to a number of factors. Consequently, all that can be expected regarding any analytical data for particular types of decomposition is that, when a particular type has proceeded to a certain extent, as measured by the analytical method, the grade must be below a certain level. Samples in which the type of decomposition being investigated has not proceeded to the extent expected to bring the material into the grade noted, have dropped into that grade because of other types of decomposition.

In the section devoted to the influence of various factors upon the rate of oxidation it is shown that acidity of the butter serum, the presence of copper and

iron contaminants, and exposure to light are particularly important. Exposure to light is probably an essential factor in the development of rancidity. This section is concluded with a discussion of the various protective wrapping materials.

Passing on to the next class of substances the decomposition of which gives rise to undesirable products, the composition of the proteins, casein and lactalbumin, so far as known, is given. The writer points out that hydrolysis alone produces material undesirable from the standpoint of flavour. The conditions governing the further breakdown of the proteins are discussed. It is shown that, neglecting feed taints, the quality of cream for buttermaking may probably be assessed on the percentage breakdown of the protein matter into amino-acids.

The important phospholipid fraction is discussed in the next section. The writer points out how this substance is probably responsible for the stabilisation of the milk emulsion, an assumption which explains well a number of facts concerning butter and its deterioration. Work which shows that lecithin decomposition is probably the main cause of the development of fishy odours in butter is reviewed. Other probable causes of fishy defects noted in the literature are the absorption of fishy odours from other materials stored near the butter, and, in the case of milk, the excretion of trimethylamine oxide in the milk by cows fed on beet waste. The writer shows that a series of observations noted in the literature lead to the conclusion that feeding linseed cake may also cause the defect in butter.

Experiments connected with the factors concerned in the development of fishiness are noted in detail. It is noted that salt and acidity, in the absence of other factors, do not cause fishiness. This is important because of the effect of salt, noted later, in restraining microbial growth. The necessary agents for the development of fishiness appear to be oxidation promoters such as metal contaminants or microbial enzymes. In the presence of such factors, salt and acidity accelerate the appearance of the defect.

The second part of the paper deals mainly with the role of microbiological agents in causing deterioration. The initial section discusses the limitations of the various methods used for examination. Later it is pointed out that, taking into consideration all the conditions of the experiments, but little reliable data is available regarding the effect of any single controlling factor on the growth of any one type of organism.

In the section dealing with the growth of moulds in butter, the data quoted indicates that a very considerable controlling influence is exerted by salt. Temperature, humidity and the degree of exposure to air are important growth-controlling factors.

Salt also exerts a considerable controlling influence on the growth of bacteria in butter. The available evidence indicates that the concentration of the salt in the serum should not be allowed to fall below about 10.5%, equivalent to 1.7% salt in butter containing 16% moisture. Consistent with the finding that salt inhibits the growth of bacteria in butter when the temperature is favourable for growth (as is usually the case after sale) is the finding that salt increases the keeping quality of butter in these circumstances.

A limited correlation has been noted by various workers between the microscopical picture and the keeping quality of butter at temperatures near room temperature.

The writer has not noted any work which indicates any correlation between bacterial types, determined by plating methods, and keeping quality. In view of the fact that the nature of the odour of all the lower fatty acids is still doubtful,

and most likely not pronounced in the case of any of the substances, the writer would draw attention to the fact that this problem needs investigation before any work is continued with the lipolytic organisms. In view of the fact, which he has pointed out earlier in the paper, that hydrolysis of the proteins certainly gives rise to at least one substance with a strong flavour, proteolytic species are important. However, proposed tests for proteolytic species afford no indication as to whether degradation further than hydrolysis will be produced by the species and thus give no indication regarding the extent to which proteolytic species are undesirable.

The writer has also drawn attention to the fact that the proposed tests for undesirable species are unsatisfactory in that they give no evidence of the numbers of organisms capable of growing in the conditions obtaining in butter.

The data published indicates that salt has a marked controlling effect on the growth of yeasts in butter, but the evidence available is insufficient to indicate whether this type of organism is of importance in causing deterioration.

BUTTER GRADING.

Any person with scientific training reading through the literature will realise that the number of grade points assigned to a sample of butter is, with the present systems of grading, dependent upon a number of quite unconnected factors. Consequently, such systems of grading form unreliable methods for the study of any one particular type of deterioration. Let us consider the system used locally: 100 points are allowed for the perfect sample of butter. Of these points 50 are allotted for flavour and aroma, 30 for body and texture, and 20 for condition, which term includes colour, salting, packing and package.

Samples graded 93 to 100 points inclusive are choice grade butter—90 to 92 inclusive are first grade—86 to 89 inclusive are second grade, and 83 to 85 inclusive are pastry grade. In other words, although 100 points are allotted for scoring purposes, not more than 20 are utilised to cover all grades.

The alteration in grade due to flavour and aroma defects is as follows: Butter perfectly neutral in flavour and aroma or possessing no undesirable flavour and aroma is classed as choice grade. Samples with a slight volatile feed taint are also included in choice grade, as this defect is said, in general, to pass off on keeping. With more definite feed taint, or slightly unclean or metallic flavour the butter is classed first grade. An increased intensity of the defects puts the butter in second grade. Advanced defects place the butter in the pastry grade.

The senses of colour-vision, taste and smell differ in acuity from one individual to another, and in the same individual from one time to another. In the section of this paper dealing with the effect of salt upon flavour is a table which illustrates how even experienced butter judges differ in their opinions. In this particular table it will be noted that judge No. 2 detected a fishy flavour in 15 samples whereas judge No. 5 noted the defect in only 7 of the same batch of samples. In consequence of the variation in the senses, defects noted by them form very poor criteria by which to judge the nature and extent of any change in dairy products. Undoubtedly, the general concensus of opinion resulting from the use of these senses must form the criteria by which the desirability or otherwise of a given change in any food product is judged. However, as these sensory impressions are not, in our present state of knowledge, susceptible of measurement, it is much more desirable for scientific purposes

to measure chemical changes which, in many cases, we can measure with a fair degree of accuracy and, in addition, obtain a general opinion regarding the effects produced on the senses by such changes which have proceeded to varying extents, the variation being measured by the chemical method.

The senses of taste and smell are often fallible in their judgment for the simple reason that many substances taste or smell similarly. Sugar, saccharin and lead acetate are all sweet, yet they have no chemical similarity. Again, substances similar chemically may have quite different odours; for example formaldehyde, HCHO, and acetaldehyde, CH_3CHO, or anisaldehyde,

$$C_6H_4 : \begin{matrix} OCH_3 \ (1) \\ CHO \ (4) \end{matrix}, \text{ and vanillin, } C_6H_3 : \begin{matrix} OH \ (1) \\ OCH_3 \ (2) \\ CHO \ (4) \end{matrix}$$

In some cases, substances which have first been considered to possess a typical smell, have later been shown to possess no smell, the smell originally associated with the substances being actually due to minute traces of impurity. A well-known case is the mousy smell associated with acetamide as it is usually obtained.

Probably the greatest difficulty associated with judgment dependent upon taste and smell is occasioned by the fact that substances present in only minute quantities may be involved; in fact, when present in large quantities substances often produce entirely different sensations to those which they produce when present in small concentrations.

A survey of the literature makes it evident that many of the changes causing deterioration of butter may be studied, to some extent at least, by accurate chemical methods.

A number of workers have attempted to correlate the grade of butter and/or cream with various products of decomposition. In general, these studies have not been productive of very satisfactory results. This is only to be expected, because the fall in grade of butter is not due to any one type of decomposition but to a number of frequently unconnected factors. What is to be expected, however, is that when any type of decomposition has proceeded beyond a certain point there will be a notable fall in grade. In the cases of the main types of decomposition, such as protein hydrolysis and fat oxidation, it will be shown in the following pages that the changes may be followed chemically, and that chemical evidence gives satisfactory indications as to whether or not further decomposition in a particular manner will cause marked changes of grade.

THE EFFECT OF SALT ON THE FLAVOUR OF BUTTER.

When the effect of salt upon the keeping quality of butter is studied a further effect of salt should also be taken into consideration. This is the effect of salt upon flavour. As the cook and the epicure well recognise, salt heightens the flavour of most food. Butter is no exception to this generalisation. Hunziker says (4):— "Yet it is a fact that salt possesses the tendency of hiding or destroying the delicate flavour and aroma and of intensifying objectionable flavours. Butter with a high salt content (above 3 per cent) usually lacks the fine and delicate flavour which is characteristic of prize-winning butter. Nor does high salt content cover up bad flavours as is popularly believed. such flavours are made more prominent by the

salty taste. The salt does not hide them and gives the butter a disagreeable coarse character. In fact, butter made from second grade cream is more palatable and sells to better advantage when not salted at all."

The effect of salt in bringing out the flavour of butter is well shown by the following data taken from a paper by Washburn & Dahlberg (5):—

Churn No.	Salt.	Score.	Judge's Comments.
3	% 0 1·72	 93·00 93·25	 Good. Will not go fishy.
2	0 2·07	91·00 91·25	Good. Tendency to fishy.
6	0 2·41	94·25 94·00	
1	0 2·51	91·75 90·75	Dry. Tendency to fishy.
4	0 3·27	92·50 92·50	Good. Good.
5	0 3·79	95·00 92·75	Extra fine aroma.

Half of the butter of each churning was salted and worked, and the other half worked unsalted.

It will be noted that in the case of churnings 3, 6 and 4, where the score of the unsalted butter is high, the score of the salted butter is practically identical. In the case of churning No. 1, where the score of the unsalted butter is lower, the salt has apparently brought out the undesirable odour and flavour. In the case of churning No. 2, the salt has brought out a suspicion of an off-odour and flavour. The salting was lighter than in the case of churning No. 1. As regards churning No. 5, the very high percentage of salt may have spoilt the odour and flavour or, what is more likely, have brought out a slight taint. Washburn and Dahlberg have not noted the effect of salt in enhancing flavour and odour in butter.

Whilst experimenting with the effect produced on odour and flavour by the addition of various substances to butter, Supplee noted that, in general, flavour and odour defects were more noticeable in the salted portion of a sample than in the unsalted portion (6). He said:—"The greater number of positive comments from the salted butter is also worthy of note, and, from what is generally known regarding the occurrence of the fishy flavour in such butter, it might tend to strengthen the trimethylamine theory of this flavour." The following table is selected from Supplee's paper because the experiments were made with butter having a lower acidity than in any other series reported, and further, the substances were added directly to the butter.

EFFECT ON THE FLAVOUR OF BUTTER MADE FROM PASTEURISED SWEET CREAM WITH 0·16 PER CENT ACID OF WORKING TRIMETHYLAMINE AND FATTY ACIDS DIRECTLY INTO THE BUTTER AT THE RATE OF 85 PARTS PER MILLION.

Sample.	Material Added.	Comments by Judges.					
		No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
ES	Nothing	...	...	...	...	...	...
E	Nothing	...	...	...	...	...	...
1ES	Trimethylamine ...	Fishy	Fishy	Fishy	Fishy	...	Fishy
1E		Fishy	Fishy	...	...	...	Fishy
2ES	Trimethylamine-lactate	Fishy	Fishy	Fishy	Fishy	...	Fishy
2E		...	Fishy	..	...	...	Fishy
3ES	Trimethylamine-butyrate	Fishy	Fishy	Fishy	Fishy	Fishy	Fishy
3E		...	Fishy	...	...	...	Fishy
4ES	Trimethylamine-oleate	Fishy	Fishy	...	...	...	...
4E		...	Fishy	...	...	...	Fishy
5ES	Trimethylamine-stearate	...	Fishy	...	Fishy	...	Fishy
5E		...	Oily	Fishy	Fishy	Fishy	Fishy
6ES	Trimethylamine and soluble fatty acids	Fishy	Fishy	Fishy	Fishy	Fishy	Fishy
6E		...	Fishy	Fishy	Fishy	...	...
7ES	Trimethylamine and insoluble fatty acids	Fishy	Fishy	...	...	Fishy	...
7E		...	Fishy	...	...	Fishy	...
8ES	Lactic acid ...	...	Fishy	...	...	...	...
8E		...	Fishy	...	...	...	...
9ES	Butyric acid ...	Fishy	...	Fishy	...	...	Fishy
9E		Fishy	...	Fishy	Fishy	Fishy	...
10ES	Oleic acid	...	...	...	Fishy	...	...
10E		...	...	...	Fishy	...	...
11ES	Soluble fatty acids	...	...	...	Fishy	...	...
11E		...	...	...	...	Fishy	...
12ES	Insoluble fatty acids	Oily	...	...	...	...	Oily
12E		Oily	...	...	...	..	...

(S following sample number indicates salted butter.)

The above table brings out very well the difference in the reactions of various judges to the same sample of butter. Whereas judge No. 2 noted a fishy defect in the case of 15 samples, judge No. 5 noted the defect in only 7 of the same samples.

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE FLAVOUR OF BUTTER.

The effect of acidity upon the flavour of butter is mentioned by Hunziker in his work "The Butter Industry" (4). Hunziker says: ". . . . . the delicate flavour and aroma characteristic of good butter are intimately related to the acids in the cream. When neutralising to a point sufficiently low to destroy practically all the acid, the delicate butter flavour usually also suffers and the resulting butter is flat and tasteless."

Hunziker's observation of the effect of neutralisation affecting the flavour is certainly correct, but, by destruction of the acid he obviously means neutralisation of the acid, and, in view of the facts that the desirable aroma of fine quality butter is generally considered to be due to the substance diacetyl and that the lower fatty acids are generally considered to have undesirable aromas, his implication that the desirable aroma is bound up with the presence of free acids seems open to question. The question of the aroma of the free fatty acids will be discussed later.

The following table, showing groups of samples arranged in order of hydrogen-ion concentration with the corresponding flavour scores, was reported by Gilmour (7).

pH Value of Butter in the Group.	No. of Samples.	Average pH Value of Group.	Variation of Individual Flavour Scores in Group.	Average Flavour Score of Group.
7·40 and over	58	7·47	168—172	170·52
7·30 and under 7·40	61	7·32	165—174	170·51
7·20 „ „ 7·30	118	7·22	165—173	170·30
7·10 „ „ 7·20	130	7·13	159—174	170·05
7·00 „ „ 7·10	156	7·02	164—173	170·08
6·90 „ „ 7·00	184	6·93	159—172	170·07
6·80 „ „ 6·90	165	6·83	162—173	169·79
6·70 „ „ 6·80	142	6·72	158—174	169·54
6·60 „ „ 6·70	133	6·63	159—172	169·26
6·50 „ „ 6·60	74	6·53	159—172	168·77
6·40 „ „ 6·50	39	6·43	148—172	167·08
<6·40	32	6·20	159—171	167·16

Gilmour commented on the above results in his summary as follows: "On correlating the pH values and the flavour scores, it was found that there was a decided tendency for the flavour score to diminish as the acidity increased—*i.e.*, as the pH value decreased."

The writer has noted a similar tendency in the case of West Australian butters (8). The following table is taken from his paper:—

pH Values.	Grade initially.			
	93	92	91	90
	%	%	%	%
>7·2	33·3	13·9	...	3·8
7·1—7·2	20·8	2·8	6·2	...
7·0—7·1	8·3	5·5	8·6	5·8
6·9—7·0	12·5	8·3	6·2	9·6
6·8—6·9	...	8·3	11·1	11·5
6·7—6·8	...	16·6	16·0	32·7
<6·7	25·0	44·4	51·9	36·5

From these results the writer concluded: ". . . . . there is quite a marked correlation between the initial flavour score and the pH values, the butters with the higher flavour scores being generally less acid than those with lower flavour scores. . . . . .

"Two points should be noted in this connection:—

(i) Is the selection of these nearly neutral, or even slightly alkaline butters due to the training of the graders to prefer this type? *or*,

(ii) Have they been chosen as the best quality material because, in neutral materials, as contrasted with acid materials, any off-flavours would not be sufficiently noticeable to command attention? . . . .

"The possibility of undesirable odours and flavours being present but masked because of the neutral condition of the material deserves investigation."

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE KEEPING QUALITY OF BUTTER.

Of all the factors studied, hydrogen-ion concentration appears to have the greatest influence on the keeping quality of butter.

Arup & Gilmour noted the controlling influence of hydrogen-ion concentration upon the keeping quality of butter (9). "Altogether, out of the 72 boxes stored only 12 depreciated in flavour by more than 2 points; of these 10 had pH below 6.7, one had pH 6.7 and one had a pH above 6.7. Further, out of the 72 boxes only four fell below export quality, and all these had low pH values. Remembering that but one-third of the butters had pH values below 6.7, the number with low pH that depreciated appreciably in flavour was out of all proportion to the depreciation of those with high pH. In agreement with this is the well-known fact that starter butters do not store so well as those made from fresh cream. This is possibly merely a more exaggerated case than the present one of pH difference.

"The conclusion arrived at is that when butter is to be cold stored, only lots of high pH should be selected."

Loftus and Hills *et alia* in their study of the factors affecting the keeping quality of butter noted the effect of hydrogen-ion concentration (10). "With the exception of the erratic result for the one butter in the pH range 5.0—5.5 there is a distinct association between pH and change of grade." Sixty-five samples were examined. The samples were stored at 12°F. for three months.

The writer examined the influence of hydrogen-ion concentration on the keeping quality of 236 churnings of butter made commercially and stored in a commercial cold store during the 1937-38 storage season (8). In storage the temperature was maintained around 10°F. The storage time varied from six to fifteen weeks, the greater number of samples being stored from eight to eleven weeks. The following table shows the percentage of samples in each pH range which fell a given number of points in score:—

Fall in Grade (pts.).	pH Values.											
	<6·2	6·2–6·3	6·3–6·4	6·4–6·5	6·5–6·6	6·6–6·7	6·7–6·8	6·8–6·9	6·9–7·0	7·0–7·1	7·1–7·2	>7·2
3 ...	50·0	12·5	...	6·6	3·7	3·6	...	4·0	..	...	7·1	7·1
2½ ...	...	...	...	...	...	...	...	...	...	...	...	14·3
2 ...	50·0	12·5	20·0	10·0	14·8	10·7	2·6	...	26·3	15·4	42·9	35·7
1½ ...	...	12·5	...	...	11·1	3·6	5·1	4·0	...	...	...	21·4
1 ...	...	25·0	20·0	33·3	18·5	39·3	41·0	20·0	31·6	30·8	21·4	21·4
½ ...	...	37·5	40·0	26·6	33·3	25·0	2·6	44·0	10·5	38·5	14·3	...
0 ...	...	...	20·0	23·3	18·5	17·9	48·7	28·0	31·6	15·4	14·3	...
Average fall	2·5	1·2	0·8	0·9	0·9	0·6	0·5	0·6	0·9	0·8	1·4	1·8

NOTE: Owing to the very small number of samples which had a pH value of 6.2 or lower, no great importance should be attached to the figures in the first column of the table.

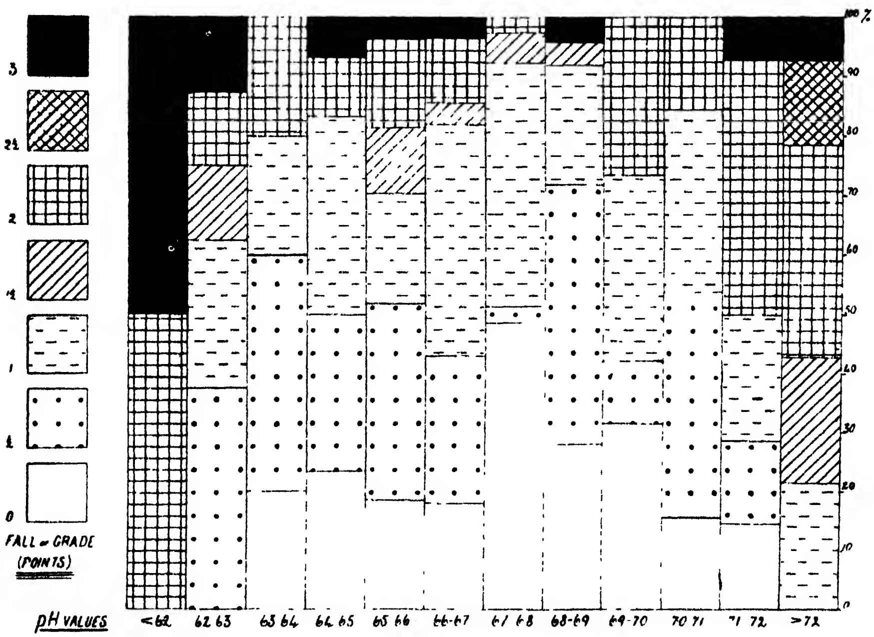
The writer concluded: "There is a marked correlation between the keeping quality in cold store and pH values. The optimum acidity for keeping quality is about pH 6.7 — 6.9." The results tabulated above are shown graphically on page 102. The butter is classed according to the number of grade points by which it deteriorated.

The writer made similar tests during the 1938-39 storage season, selecting for examination the samples which just fell in the first grade class, i.e. 91 score. The results obtained amply verified the above findings, the samples within the pH range of 6.7 — 6.9 again showing best keeping quality.

Similar findings to those of the writer are mentioned in America by Parsons (11). Five thousand samples of butter kept at 70°F. for eight days only lost on an average 1 point in score when the pH value of the fresh butter was 6.6 to 7.0, and 0.5 point when the pH value was 6.7.

It is very interesting to compare the writer's results with those reported by Parsons. The writer's experiment was made with butter samples held in cold store. Parsons reports that his samples were stored at 70°F. As the pH value for optimum keeping quality was the same in both experiments, this indicates that it is independent of the temperature of storage.

GRAPH SHOWING CORRELATION BETWEEN pH VALUES AND KEEPING QUALITY.



THE EFFECT OF IRON AND COPPER ON THE KEEPING QUALITY OF BUTTER.

Owing to the fact that milk contains copper and iron in traces, one would expect traces of these metals in even the best quality butter. Williams gives the following data (12).

Superfine butter—Copper 0.2—0.25 p.p.m.
Iron 0.5—1.00 p.p.m.

Second Grade — Copper normal.
Iron 1.2—1.7 p.p.m.

Carefully designed experiments were made by Rogers *et alia* to determine the effect of iron on the keeping quality of butter (13). The butter samples were made from pasteurised ripened cream which had been carefully selected as having come in contact with no vessels except such as were well tinned. In each test the cream was divided into two portions after pasteurisation and to one portion ferrous sulphate or lactate was added. During the butter-making process care was taken to avoid contact of the materials with iron. The butters were worked the same amount, salted the same, and washed with the same amount of water and the same number of revolutions in the wash water. The samples were stored packed in glass jars with glass tops.

Unfortunately, the acidity of all the samples was too high for the butters to possess good keeping quality and marked deterioration took place in all cases. However, in every instance, on first scoring, the butters to which iron had been added scored lower than their controls. The same observation was noted in most cases on the second and third scoring, the most noticeable feature being that the butters to which iron had been added showed a much faster deterioration than the control butters.

The same workers carried out experiments to determine the effect of copper on the keeping quality (13). The same remarks as for the iron experiments are applicable.

Davies reports analytical data for the copper and iron content of various samples of Australian and New Zealand butter, together with remarks on the flavour (14). The following data is taken from his paper:—

Source and No. of Sample.	Cu Content (p.p.m.).	Fe Content (p.p.m.).	Acidity (mls. N/1/100 gms.)	Remarks.
N.Z. 1 ...	9·30	...	...	Fishy, quickly followed by tallowiness (whey butter).
2 ...	1·40	...	1·77	No taint.
3 ...	2·00	...	9·10	Slightly fishy.
4 ...	1·20	...	...	No taint.
A. 1 ...	1·60	...	3·08	No taint.
2 ...	2·00	6·60	0·93	Fishy.
3 ...	0·90	5·50	1·42	Fishy.
4 ...	2·20	2·50	1·14	Fishy.
5 ...	1·70	3·80	1·32	No taint.
6 ...	3·20	1·70	3·45	Fishy.
7 ...	2·30	1·30	2·48	Fishy.
8 ...	Trace	3·00	7·90	Acid and off flavour.
9 ...	Trace	2·40	8·00	Acid and off flavour.
10 ...	1·30	1·90	...	Good samples of Australian butter.
11 ...	1·80	1·80	...	
12 ...	1·30	1·10	...	
13 ...	1·64	2·30	...	
14 ...	1·60	1·60	...	
15 ...	3·60	2·20	...	Fishy.
16 ...	2·00	0·90	...	Slightly fishy.
17 ...	2·40	2·40	...	Fishy.

In the above table it will be noted that no sample having a copper content under 1.8 p.p.m. showed defects providing that the other factors controlling deterioration were satisfactory. All samples having 2.0 p.p.m. or more of copper showed defects. It will also be noted that one sample containing 3.80 p.p.m. of iron, the other factors controlling deterioration being satisfactory, showed no defects, but a sample containing 5.50 p.p.m. of iron deteriorated.

Loftus Hills *et alia* report the following data (10):

Copper (p.p.m.).	Change of Grade (points).	pH.
0·36	1	6·9
0·36	0	6·4
0·38	0	6·3
0·38	—1	6·4
0·42	1	6·4
0·48	0	7·5
0·48	—1	6·7
0·50	—1	6·3
0·52	—1	6·2
0·52	—2	6·4
0·56	—1	7·0
0·58	—2½	5·6

The workers remark that the above table "is suggestive in that it indicates that the combined effect of acidity and copper content may be important in relation to keeping quality."

One point which has been brought forward certainly deserves attention; i.e. will the copper and iron exert little or no controlling effect on the rate of deterioration provided the acidity of the sample is correctly adjusted, or, will they have a controlling influence irrespective of the acidity? It is to be expected that because the acidity will influence the solubility of the metals, adjustment of the acidity will largely control their influence.

THE EFFECT OF TEMPERATURE UPON THE KEEPING QUALITY OF BUTTER.

When conditions in the butter are suitable for decomposition, the temperature of storage exerts a marked effect upon the rate of deterioration. The following data, taken from the work of Rogers *et alia,* shows this very markedly. (74).

AVERAGE DETERIORATION OF BUTTER AFTER STORAGE AT VARIOUS TEMPERATURES.

Kind of Butter.	Points lost after storage at—		
	0° F.	10° F.	20° F.
Raw Cream Butter—			
Creamery A	5·0	5·3	5·8
Creamery D	1·7	4·1	3·3
All Samples	3·2	4·6	4·8
Pasteurised Ripened Cream—			
Creamery B	2·2	3·0	5·1
Creamery E	1·7	3·6	4·0
All Samples	2·0	3·3	4·6
Pasteurised Unripened Cream—			
Creamery C	·6	1·0	1·5
Creamery D	·4	1·0	1·6
All Samples	·5	1·0	1·6

The above table indicates that, when factors which cause deterioration of butter are present, the lower the temperature of storage the slower the rate of deterioration.

When careful attention is paid to the exclusion of factors causing deterioration, the amount of deterioration may be negligible with storage temperatures as high as at least 10°F. The writer's work, previously mentioned, indicates that, with the pH adjusted between 6.7 and 6.9, over 90% of the samples may be expected to deteriorate by only 1 point or less during ten weeks cold storage at 10°F. (8).

THE GAS-CONTENT OF BUTTER.

Russel and Hastings state that "Butter contains ten per cent of air in the form of minute bubbles (44).

Rogers *et alia* examined the air enclosed in canned butter (13). As it seems highly probable that a portion of the gas obtained from the cans may not have been actually contained in the butter, the results of these workers will not be presented.

According to Pickerill and Guthrie the air-content of butter varies from 0.5 to 6.0% (in one table) and from 4.0 to 14.9% (in another table, older samples) and has an average air content of about 4% (45).

A range of air content from 1.3 to 8.4% with a mean of about 4% was noted by Rahn and Mohr (46).

Guthrie measured the volume of air contained in butter by noting the volume which could be withdrawn from it under a vacuum of 25 mm., the temperature being maintained steady at some point between 39 and 49°C. (47). He noted that in fairly well-worked butter the air content varied from 2.854 ccs. to 6.421 ccs. per 100 gms. butter, the average content being 4.651 ccs. In thoroughly worked butter the air content varied from 4.174 ccs. to 6.703 ccs., the average content being 5.374 ccs.

Arup and Gilmour made determinations of the amount of air contained in Irish butter by comparing the specific volume of the butter in the natural state with the specific volume after melting at a low temperature and allowing the contained air to escape (9). The results obtained varied from 1.6 to 5.2 ccs. air per 100 gms. of butter; the average content was about 4ccs.

From the above information it will be seen that the air content of butter averages about 4-5 ccs. per 100 gms. butter. A simple calculation will show that the greater part of the air is not contained in the serum. The moisture content of butter is about 15 to 16%, so that 100 gms. butter contains between 15 and 16 ccs. water. At 20°C. one volume of water dissolves 0.017 volume of air at standard pressure, so that 15 ccs. of water will dissolve 0.26 ccs. of air. Thus it can be seen that practically the whole of the air must be incorporated in the butter in the form of very small bubbles.

From what has been said it will be realised that butterfat is exposed to air, not only at the surface of the package, but also at the surface of innumerable air bubbles included in the mass of the butter. Since the surface exposed by a given volume of substance to a second substance in which it is enclosed rapidly increases as the degree of subdivision of the enclosed substances increases, it will be realised that the surface of butterfat exposed to the air is large; this is a condition very suitable for oxidation of the butterfat.

The Effect of Storage on the Gas-content of Butter.

Dyer has studied the changes which take place in the gas-content of butter during storage (48). The butter samples were stored in glass tubes, any free air above the surface of the butter being displaced by pure neutral paraffin oil. When it was desired to analyse the gas-content of a sample of butter, the gas was removed from the tube with a Töpler pump after the sample had been

warmed, and analysed with the usual Hempel gas apparatus. Dyer noted that: "The composition of the air confined within a package of pasteurised sweet-cream butter known to contain bacteria and made from cream having an acidity of 0.11% (calculated as lactic acid) showed little or no variation from its original composition after successive periods of storage, aggregating six months, at a temperature of 0°F. ..... A portion of this same sample of sweet-cream butter when kept at a temperature of 32°F. showed a decided change in the original composition of the enclosed air, a change which was still further increased when the butter remained for a short time at room temperature. This change in the composition of the air originally incorporated into the butter was expressed by a decrease in the percentage of oxygen and a corresponding increase in the percentage of carbon dioxide. This sample of sweet cream butter still possessed a good score after six months' storage at a temperature of 0°F., there being no indication of any undesirable flavour.

"The change in the composition of the air initially inclosed within a package of butter made from sweet cream and churned immediately after the addition of 15% of a commercial starter showed but little variation from that observed in the sample of sweet cream butter when the two samples were kept under comparable conditions, both being in storage at a temperature of 0°F., although the acidity of the cream in the first case was somewhat higher (0.25%) than that of the cream from which the sweet-cream butter was made. This sample of butter also displayed good keeping qualities during its storage period of nearly seven months at a temperature of 0°F."

The following table taken from Dyer's paper shows the results for the analysis of gas samples extracted from sweet-cream butter.

ANALYSIS OF "AIR" EXTRACTED FROM SWEET-CREAM BUTTER.

(Calculated to 0° C. and 760 mm. Acidity of Cream as Lactic Acid, 0·11%; Salt, 1·21%; Curd, 0·58%.)

Number of Bacteria per gm.	Time Stored at—			Oxygen.	Carbon Dioxide.
	0° F.	32° F.	Room temp.		
	days.	days.	hours.	%	%
9,050,000	0	0	0	25·15	2·89
	0	2½	1	22·23	4·51
	0	15	1	15·96	7·58
	0	41	1	9·86	11·91
	0	57	1	5·49	15·24
	81	0	1	25·51	1·49
	81	1	1	22·70	2·02
132,000	81	13	1	20·45	2·86
	110	0	5	20·62	2·85
	110	1	1	23·00	2·73
	150	0	2	24·18	1·62
	180	0	1	25·11	0·57

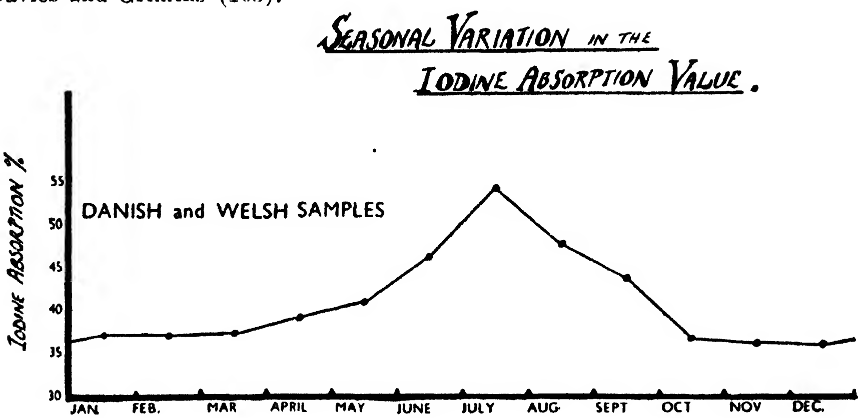
THE COMPOSITION OF BUTTERFAT.

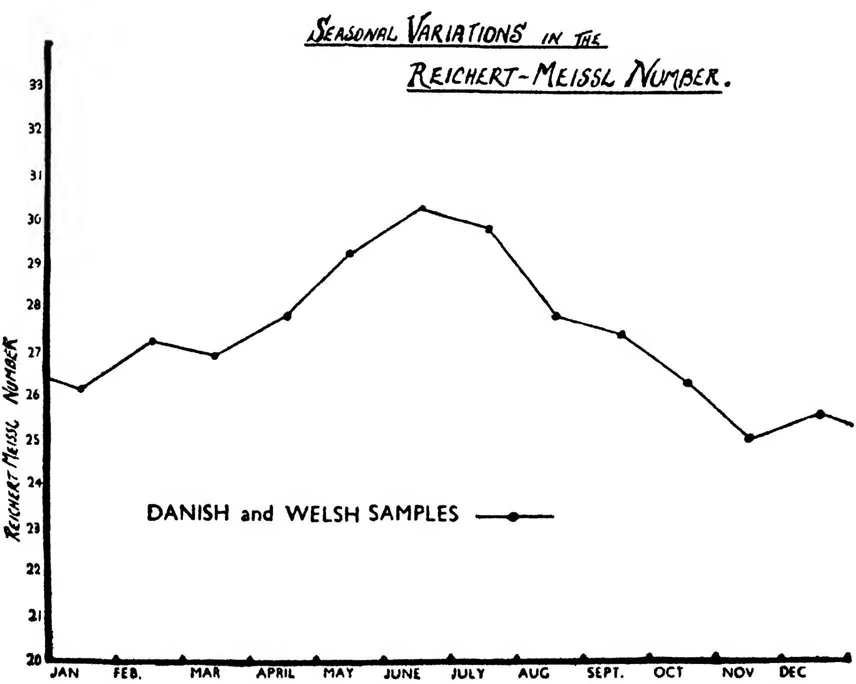
Butter contains about 80-85% butterfat. It is present in milk as an emulsion in a continuous aqueous phase, stabilised probably, as will be mentioned later, by lecithin. In the churning process the emulsion is reversed, and the water is found finely dispersed throughout the fat which is now the continuous phase. The size of the droplets is very small. Hunziker says they vary in size from less than 1 micron to about 15 microns (4). The substance forming

the stabilising membrane in milk and cream appears to be mainly destroyed during the butter-making process, probably during the heat-treatments, for upon warming butter just sufficiently to melt the fat, about 40—45°C., the fat and aqueous phases readily separate into two layers.

The determination of the composition of most fats is difficult. That the relative proportions of the constituents in butterfat vary from sample to sample is obvious from the variation of the several usually-determined analytical figures such as the Reichert-Meissl, Polenske, iodine and saponification values, etc., and from the variation of its physical properties such as melting-point and refractive index.

The following graphs, showing the variation of the iodine absorption value and the Reichert-Meissl value of Danish and Welsh butter, was presented by Davies and Griffiths (103).





The relative proportions of the glycerides have been examined by various workers. The range of probable values for the percentages of the various fatty acids is given in the following table which has been drawn up after a critical perusal of the literature on the subject. The table also shows the melting point of each fatty acid and the melting point of the corresponding triglyceride.

Fatty Acid.	Proportions.	M.P. Acid.	M.P. Glyceride.
Butyric	2·0— 5·5	—7	...
Caproic	1·0— 3·5	—8	—25
Caprylic	0·5— 1·5	16·5	8
Capric	0·3— 3·0	31·3	31
Lauric	2·5— 7·5	43·6	45
Myristic	9·5—22·5	53·8	56
Palmitic	15·0—38·5	62·6	63
Stearic	2·0—20·5	69·3	71·6
Oleic	20·0—48·0	13	...

The above table indicates that oleic acid is the one unsaturated acid generally considered to be present. If this assumption is correct the iodine value of butterfat gives a measure of the quantity of this glyceride present in the sample. If X be the percentage of this glyceride present in the sample and Y the iodine value of the sample, then

$$\frac{X}{100} = \frac{Y}{86.2}$$

86.2 being the iodine value of pure olein.

The statement that oleic acid is the only unsaturated fatty acid in butterfat, however, is not unchallenged.

Laxa and Koneeny claim that an examination of the fatty acids of the liquid fat of separator slime showed that they contained 49.65% erucic acid and 21.24% oleic acid (16). Hilditch and Jones claim to have isolated as much as 4% of linolenic acid from butter (17). This subject will be mentioned again later.

The above formula for calculating the percentage of olein in butterfat only applies if the oleic acid is present as the normal compound. Reports of work with the isomers of oleic acid indicate that the farther the double bond is removed from the COOH group the nearer the iodine value is to the theoretical value. Normal oleic acid has an iodine value of 90, but 2 : 3 oleic acid has a Hübl value of 6.6, Wijs value of 20.4 and Hanus value of 1.9 (18, 19).

The iodine value of butterfat is important insofar as it gives a measure of the greater part of the low-melting point fractions. The relationship between the hardness of the butter and butterfat and the iodine number of the butterfat has been studied by Coulter and Hill (20). It was found that when a standard churning and working procedure is used, the hardness of butter is directly proportional to the hardness of the butterfat. Further, there is a highly significant correlation between the hardness of the butterfat and the iodine value of the butterfat. The data reported by Coulter and Hill shows that the relationship between the iodine value and the hardness of the butterfat is curvilinear, the hardness of the butterfat increasing very rapidly as the iodine value drops below 40.

Insofar as the iodine value is a measure of the unsaturated fraction of the glycerides, it is a measure of the portion most liable to oxidation and, possibly, a measure of the portion most active in taking up odours and flavours.

The feeding of the animals has a marked influence on the iodine value of the butterfat. This subject has been studied at the Stockholm University (21). When animals were fed on lucerne in the bud up to the full bloom stage or on young clover in bud or beginning to flower, the iodine value of the butterfat averaged about 45-47. To fix the iodine value at about 35-36 the greenstuff had to be reduced to 42-43 per cent. of the total ration.

An important point brought out by the last mentioned paper is the correlation between high iodine values of the butterfat and the development of fishy flavours in the butter.

Hill and Palmer noted that the constants of the butterfat were influenced by the feed consumed by the cows (22). The following table taken from their work shows the effect of feeding linseed oil upon the chemical constants and hardness of the butterfat.

Group.	Amount of Oil Fed.	Chemical Constants of Fat.			Relative Fat Hardness.
		Sap. Value.	I_2 Value.	R.M. Value.	
	lbs.		%		gms.
Cow 419 ...	0·0	231·9	34·00	28 81	1138
	0·9	227·2	42·21	27·63	922
Difference	...	—4·7	+ 8·21	—0·18	—216
Cow 151 ...	0·0	233·7	29·29	29·20	1885
	0 8	229·7	41·17	30·11	1047
Difference	...	—4·0	+11·88	+0·91	—838
V.	0·0	227·7	38·17	26·33	1126
	1·25	219·1	54·28	24·34	771
Difference	...	—8·6	+ 16·11	—1·99	—355
VI.	0·0	226·8	42·45	25·73	725
	1·25	218·6	50·85	22·87	685
Difference	...	—8·2	+8 40	—2 92	—40

The mean difference between the iodine and the thiocyanate values of the butterfat for the periods of basal ration feeding which preceded and followed the linseed oil test feed was 3.53. During the oil feeding period it was 4.98, showing that the linseed oil causes a definite rise in the proportion of fatty acids less saturated that oleic acid.

It seems probable that the glyceride of linolenic acid was secreted in the milk as a result of the oil-feeding. The importance of this in connection with the development of the fishy defect of butter will be discussed later.

Butterfat is characterised by a high Reichert-Meissl value. It has been found that butyric, caproic, caprylic and capric acids give Reichert-Meissl values. Thus this constant is:—

(1) A measure of the low-melting point constituents of the fat other than olein. Coulter and Hill have shown that large increases in the Reichert-Meissl value could be correlated with a low-melting point of the fat (20). Also, the graph reported in their paper showing the hardness of butterfat correlated with the iodine value indicates that some factor other than iodine value is involved.

(2) It is a measure of the constituents which upon hydrolysis will set free acids generally considered to have pronounced aromas, The aromas of the lower fatty acids have been described by various workers as follows:—

Butyric acid.—Odour resembling acetic acid, or slightly rancid. Has an unpleasant rancid odour—in the presence of ammonia like that of perspiration. A very disagreeable odour like that of rancid butter and stale perspiration. A liquid with a characteristic smell which is specially developed in dilute solution; the anhydrous acid has a sharp acid smell, the characteristic smell being hardly perceptible. An addition of 0.06 per cent. imparted to a non-rancid lard a pronounced odour which was distinctly different from that of a rancid control.

Caproic acid.—Odour of sweat. Like valeric acid has a very unpleasant and persistent odour of perspiration and rancid butter. An oily liquid with an unpleasant goat-like smell. It possessed a strong, disagreeable odour, which was in no way similar, however, to the rancid odour; in the amount of 1 per cent. it imparted to a sweet lard a sour odour totally unlike that of a rancid control.

Caprylic acid.—Odour of sweat. A faint unpleasant odour of sweat and a sharp rancid taste. Its odour was similar to, but stronger than, that of pelargonic acid, and somewhat suggestive of coconut: when added to sweet lard in the amount of 1 per cent. it imparted to the lard an odour weaker than that of a rancid control and of a different type. (In connection with the last opinion, the same worker said of pelargonic acid: It was found to have a mild odour, and in small quantities was without appreciable effect on the odour of a non-rancid lard to which it had been added).

Capric acid.—Odour of sweat, less pronounced than in the above. A faint goat-like odour.

To the writer it seems very doubtful whether any of the above acids in a perfectly pure condition have any pronounced disagreeable odours and flavours. If a Reichert-Meissl test is made upon butterfat from perfectly fresh material there is no pronounced odour or flavour other than a sharp acid odour in the distillate, and yet all the above acids should be present in the distillate.

THE OXIDATION OF BUTTERFAT.

In the first place it must be noted that much of the literature published in connection with the deterioration of butterfat, particularly the earlier work, is most difficult to review because of the confusion of the terms rancid, oxidised, etc.

It is very difficult to prepare a sample of pure butterfat, meaning by that phrase a pure sample of the glycerides of the fatty acids. As ordinarily obtained, butterfat contains dissolved in it vitamine-A in small quantities and varying quantities of the phospholipids. It seems doubtful whether any experiments have yet been made on butterfat which has been freed from both these substances. The bleaching of the colour of the fat phase is not due to oxidation of the fat but to oxidation of the carotinoid materials dissolved in the fat. It follows that the bleaching does not necessarily indicate any change in the nature of the glycerides. It may be that actually oxidation of these materials in the fat takes place before the fat itself is attacked. It is very likely that in butter, and more particularly in milk, there may be present substances which will absorb the oxygen preferentially to the fat, and that the fat itself will not start to oxidise until these other materials have been first oxidised, or at least mainly oxidised. In the case of milk, a number of observers consider that the oxidised flavour becomes apparent at about the time the ascorbic acid is practically all oxidised (23).

The experiments which have been made to study the oxidation of more or less pure butterfat, have usually been made at elevated temperatures. In such conditions it is possible that inter-molecular changes take place between the dissolved substances and the fat, and, of course, the same changes or similar changes may take place at more normal temperatures, but at a slower rate. In any case, the course of oxidation of butterfat at elevated temperatures may be quite different from the course at lower temperatures, and the products formed in a more or less pure sample of butterfat may be quite different from the products formed in the presence of other milk constituents.

The latter observation appears to be borne out in practice by the observations of Hunziker and Hosman (24). These workers conclude that the tallowy flavour usually associated with oxidation of the butterfat is produced by compounds of glycollic acid with fatty acids. In the case of pure butterfat they suggest the glycollic acid is produced by oxidation of free glycerol derived from the fat, but in the case of butter the glycollic acid is probably formed by oxidation of lactose. They found that a distinctly tallowy defect could be produced by the addition to butterfat of 0.25% of the glycollic acid ester of oleic acid.

Briggs made experiments with the fatty phase of butter separated from the aqueous phase (25). He observed that, when the material was held at 100°C. and well stirred in an atmosphere of oxygen, there was a so-called "induction period" prior to the active absorption of oxygen. Other workers have observed the same phenomenon (26,27). Briggs showed that during the induction period changes were actually taking place in the fat, the peroxide test giving positive findings early in the process. The following is a set of peroxide values reported by Briggs (28):—

Time (hours).	Peroxide Content ($\% \times 10^4$).	Time (hours).	Peroxide Content ($\% \times 10^4$).
0	...	10	18·0
1	5·0	11	19·2
2	3·8	12	22·3
3	7·1	13	21·1
4	8·8	14	23·7
5	10·2	15	32·8
6	10·1	16	30·6
7	11·0	17	33·1
8	14·5	18	47·8
9	15·0	19	349·2

"Induction period," 18¾ hours.

It will be noted that after the "induction period" the rate of increase in the peroxide value was very rapid.

A number of explanations are possible for the phenomena noted above. In the first place, the method of measurement of oxygen volumes may not have been sufficiently sensitive to note the small oxygen absorption during the induction period. On the other hand there may have been no absorption of oxygen from the atmosphere, with oxidation of the fat being due to an inter-molecular change with other materials dissolved in the fat. The change taking place during the induction period may be oxidation of constituents other than the fat and, when the first small quantity of fat is oxidised this may act as a catalyst to the remainder. This appears to be borne out by the fact that small quantities of old butterfat materially shorten the induction period of fresh butterfat.

Odours and flavours due to Oxidation:

Oxidation of oleic acid itself gives rise to substances having very strong odours. It is likely that the first stage in the oxidation of this acid consists in the addition of oxygen at the unsaturated bond as follows:—

$$CH_3\,(CH_2)_7\,CH = CH\,(CH_2)_7\,COOH$$
$$\downarrow$$
$$\begin{array}{c} CH_3\,(CH_2)_7\,CH - CH\,(CH_2)_7\,COOH \\ \qquad\qquad | \qquad\quad | \qquad\qquad \\ \qquad\qquad O - O \qquad\qquad \end{array}$$

Further change can easily give rise to the following compounds

$CH_3\,(CH_2)_7\,CHO$,	$CHO\,(CH_2)_7\,COOH$
nonyl aldehyde	azelaic half-aldehyde

and

$CH_3\,(CH_2)_7\,COOH$,	$COOH\,(CH_2)_7\,COOH$
nonylic or pelargonic acid	azelaic acid.

This sequence of changes for the oxidation of oleic acid, i.e., absorption of oxygen with the formation of peroxides followed by breakdown of the peroxide to give aldehydes and acids, is strengthened by the findings of Briggs that, whereas positive peroxide tests were obtainable as soon as oxidation of the fat commenced, tests depending upon aldehydes were only obtainable after the lapse of some time (28).

Briggs notes that it has been shown that among the chief decomposition products of oleic acid are to be found oxido-oleic acid, dihydroxy-stearic acid, azelaic and nonylic acid (28). The aldehydes have strong odours in small concentrations. In the case of nonyl or pelargonic aldehyde small quantities impart to substances a characteristic fine odour and it is used at a concentration of 1 : 1000 in artificial rose attar (49). Powick says of the aldehyde: "Its odour was distinctly suggestive of the odour of rancidity, but of a rancid odour modified by a somewhat pleasing and fragrant quality. When added in small quantity to a sweet lard it imparted to the lard an odour very suggestive of the rancid odour, but lacking in some indefinable quality" (42). Powick's sample of the aldehyde was probably impure. Harries and Turk described azelaic half-aldehyde as a white solid that is ordinarily possessed of a weak odour, but which gives off a strong rose-like odour when warmed (50).

Powick examined a large number of known fat decomposition products (42). Whilst some of the compounds examined may not have been perfectly pure—some showed a slight range of boiling point—it can be assumed that they were largely pure, and, if the odour associated with rancidity was not characteristic of them, they could be assumed not responsible for this defect in butter. Powick says: "As a result of the direct examination of the following compounds, it appears that none of them contributes appreciably, if at all, toward the rancid odour of fats:

Hydroxystearic acid	Heptylic acid	Butyric aldehyde
Dihydroxystearic acid	Caprylic acid	Acrolein
Diketostearic acid	Nonylic acid	Crotonic aldehyde
Formic acid	Azelaic acid	Methylglyoxal
Acetic acid	Acrylic acid	Dihydroxyacetone
Butyric acid	Formaldehyde	
Caproic acid	Acetaldehyde	

"It also appears, on theoretical grounds, that neither ketoxystearic acid nor azelaic half-aldehyde contributes to the odour of rancid fats. Direct examination of nonylic aldehyde, on the other hand, suggests that this compound may be partly responsible for the rancid odour." On the other hand, "The odour of heptylic aldehyde in itself and in presence of fresh fats is sufficiently suggestive of the rancid odour to establish the reasonableness of Scala's contention that it is the component of rancid fats that is primarily responsible for their rancid odour."

It is difficult to understand how normal oleic acid can give rise to heptylic aldehyde. The production of the aldehyde would involve either breakdown at a saturated linkage in the molecule or shift in the point of unsaturation during the oxidation process. It seems more reasonable to assume that breakdown of normal oleic acid gives rise to nonylic aldehyde and azelaic half-aldehyde and that the hepylic aldehyde is produced from an isomeric form of oleic acid.

The old contention that rancidity is due mainly to free butyric acid is certainly not correct. The flavour and odour of pure butyric acid, either concentrated or in dilute solution is not so obnoxious as past workers would have us believe. Powick's observation is noted above. Butyric acid is used commercially in artificial butter flavours, and the finer the quality of the material the better the odour. The following formula for "Butterscotch Basic Ether" is taken from Walter's "Manuel for the Essence Industry."

Ethyl oenanthate	½lb.
Ethyl pelargonate	1lb.
Butyl butyrate	1¼lb.
Amyl acetate	1¼lb.
Ethyl butyrate	1½lb.
Butyric acid	2½lb.

Thurston *et alia* have shown that the typical "oxidised flavour" of milk products is probably associated with compounds formed by the oxidation of lecithin (51). These workers washed cream with water 14 times, separating the cream after washing. The oiling-off of the cream towards the end of the process indicated the removal of the stabilising membrane from the fat globules. No organic phosphorus could be detected in the washed butterfat. The washed butterfat was dispersed in fresh skim milk of good flavour by "homogenising" at a pressure adjusted to give fat globules of the size found in the original milk. After 0.01 per cent. copper had been added to it and air bubbled through it for 24 hours, it had no "oxidised flavour." Fresh milk, similarly treated, had a strong "oxidised flavour." These workers also noted that the strength of the "oxidised flavour" developed in a milk product was influenced by the lecithin content, the greater the lecithin content the stronger the flavour developed.

The Kreis Test.

Powick found that neither any of the fat decomposition products mentioned above nor oleic acid ozonide is responsible for the development of the colour in the Kreis test (42). He considers that, on theoretical grounds, oleic acid peroxide, azelaic half aldehyde and ketoxy-stearic acid may also be eliminated as being responsible for the test, whilst glyceric aldehyde is eliminated on the basis of statements in the literature.

He found that the colour obtained in the Kreis test with rancid fats is spectroscopically identical with that obtained in the Kreis test with mixtures of acrolein and hydrogen peroxide, and that the substance responsible for the colour

production is epihydrin aldehyde $\underbrace{CH_2\text{—}CH}_{O}.CHO$. The constituent of rancid fats that causes the Kreis test is not the free aldehyde, which is too unstable to isolate, but it is certain that the substance gives rise to the aldehyde when the rancid fat containing it is brought into contact with the strong hydrochloric acid used in the Kreis test. Powick believes the substance in the fat is the acetal of epihydrin aldehyde. Thus, the above-mentioned secondary reactions are not responsible for the colour tests. Briggs suggests the aldehyde may be derived either from linolenic acid, which, as mentioned previously, is found in butterfat at least on some occasions, or, from the carotinoid pigments. On the other hand, Powick obtained positive Kreis tests with oxidised oleic acid, presumably free of the pigments and linolenic acid.

From what has been said it will be seen that the substance responsible for the aroma of rancid fat is not the same substance as gives the Kreis test. Further, a large number of compounds react with the Kreis reagent to give a red colour. These colours are distinguishable from the colour developed with rancid fats only by spectroscopic means (?). Thus many samples of non-rancid cotton seed oil give positive Kreis tests as judged visually. However, Powick considers the test is satisfactory when the colour is examined spectroscopically.

The Correlation between Chemical Tests for Oxidation and Flavour Defects.

Wiley determined the fat-aldehyde values of butter samples of various grades (52). The following data was reported:—

Grade after Storage.	Fat-aldehyde Values.	Mean.
85–86	5·0, 3·6	4·3
86–87	4·2, 5·0, 8·3, 4·2, 1·9, 5·6, 6·3, 6·3, 5·0	5·2
87–88	6·3, 6·3, 8·3, 8·3, 8·3, 5·0, 2·8, 1·7, 2·5, 3·1, 3·1 ...	5·1
88–89	6·3, 4·2, 5·0, 3·1, 2·8, 8·3, 4·2, 2·3	4·5
89–90	5·0, 7·1, 4·2, 2·8, 4·2	4·6
90–91	4·2, 2·8, 3·1, 0·8, 0·6, 0·2, 0·3, 0·1, 0·1, 0·2, 0·5 ...	1·1
91–92	0, 0·03, 0, 0·13, 0·09, 0·13, 0·16, 0, 0, 0, 0, 0, 0·13, 0·08, 0, 0·4, 0·03, 0 7	0·15
92	0, 0, 0, 0, 0	0

The results indicate a wide variation in the fat aldehyde values in each grade. This is only to be expected, for deterioration of butter is not due to the one factor—oxidation of the fat—but to a number of factors. However, one would expect that when oxidation had proceeded to certain extents, the grade would then be below certain levels. Let us consider the above data. In no case when the butter was first grade, i.e., it had 90 points or more, did the fat aldehyde value exceed 5.

The following table might be drawn up:—

Grade (points).	Maximum Fat Aldehyde Value.
92 or more	0
91	0·7
90	4·2
89	7·1

Holm *et alia* noted that: "The general similarity in the rates of deterioration determined by the loss in score and by the development of peroxide, throughout the period of storage, in spite of the fact that in scoring all off-flavours and odours are taken into consideration, seems to verify the hypothesis that there is a direct relationship between the rate of oxidation and loss in score, or stated more directly, the oxidation reaction seems to underlie the various changes that are responsible for the loss in score.

A measure of the rate of oxidation of butterfat seems, therefore, to be a direct measure of the rate of deterioration even though the direct end product of this reaction—tallowiness—may not be noted in the scoring" (53).

From the data included in this paper, the writer concludes that there are two main types of reactions responsible for the deterioration of butter: oxidative and hydrolytic. These reactions, at least in the majority of instances, are almost certainly not interdependent; almost as certainly they are proceeding simultaneously. As a consequence the writer regards the ideas of Holm *et alia* as fundamentally unsound.

The Influence of Various Factors on the Rate of Oxidation.

Holm *et alia* noted that the rates of deterioration of sweet cream butters and butters made from creams of less than 0.20 per cent. acidity, developed by pure cultures added to sweet creams, were practically identical.

Butters made from cream of 0.3 per cent. or greater acidity were found to be inferior in keeping quality to those made from sweet cream.

The same workers noted that an acid condition in the material is apparently the requisite for the development of fishy flavours. The amount of peroxide developed in sweet cream butters was often equal to or greater at the end of the storage period, than the amounts in the acid-cream butters when the latter developed a fishy flavour, yet none of the butters made from cream of an acidity of 0.2 per cent. or less developed a fishy flavour.

Wiley carried out experiments using the fat-aldehyde value as a measure of the degree of oxidation of the butterfat (52). His results showed that acidity, the presence of materials derived from the starter organisms, salt, and low temperatures of pasteurisation all favour oxidation. The starter organisms elaborate some material which favours oxidation, and is destroyed by pasteurisation. The pro-oxidant is neither diacetyl nor acetoin. The most important factors are metallic contaminants and the extent of exposure to light. For a review of the literature on the effect of light on oxidation of butterfat, Stebnitz and Sommer's paper, "The Oxidation of Butterfat," may be consulted (29). For a review of the literature on the effect of metals on the oxidation of butterfat, the paper "Factors Influencing the Initial Induction Period in the Oxidation of Milk Fat," by Henderson and Roadhouse may be consulted (30).

Briggs' experiments with the fatty material may be mentioned (25). He reported the following data showing the reduction in the duration of the "induction period," the material being stirred in an atmosphere of oxygen and maintained at a temperature of 100°C.

INFLUENCE OF METALS.

Experiment.	Con. of Catalyst.	Ind. period (hours).
Control (*a*)	...	21½
Control (*b*)	...	19¾
Sodium vanadate	$4 : 10^6$	2½
Copper lactate	$4 : 10^6$	3
Iron lactate	$4 : 10^6$	15
Nickel sulphate (*a*)	$4 : 10^6$	18
Nickel sulphate (*b*)	$4 : 10^6$	19
Zinc lactate	$4 : 10^6$	25
Control	...	14½
Copper lactate	$1 : 10^6$	3¾
Copper lactate	$1 : 10^7$	8
Copper lactate	$1 : 10^7$	8¼

INFLUENCE OF METALS—*continued.*

Experiment.	Con. of Catalyst.	Ind. period (hours).
Copper lactate	$\cdot 5 : 10^7$	10
Copper lactate	$\cdot 25 : 10^7$	11
Control	...	25
Copper lactate	$1 : 10^6$	3½
Sodium pyrophosphate	$2 : 10^6$	
Copper lactate	$1 : 10^6$	1¾
Sodium pyrophosphate	$2 : 10^6$	
3 controls	...	Mean 17¼
Iron lactate	$4 : 10^6$	13½
Iron lactate	$7 : 10^6$	12½

The table shows that copper lactate at a concentration of $1{:}40 \times 10^6$ had a very appreciable effect in reducing the duration of the "induction period." The attempts to diminish the action of the copper by formation of the pyrophosphate were unavailing. The effect of nickel salts was slight and zinc lactate appeared to have a slight retarding effect and increased the duration of the "induction period."

Consistent with the findings that traces of copper accelerate the production of oxidation defects, is the fact that copper in traces raises the redox potential of milk products (31). Further, factors which will lower the redox potential such as large numbers of bacteria in milk (32), or the addition of reducing substances to cream (33), will prevent the development of defects due to oxidation.

The following data shows the effect of adding copper to milk and also the effect of bacteria (34).

OXIDATION—REDUCTION POTENTIAL OF MIXED COWS' MILK.

Time elapsing after setting sample. (hours)	Samples stored at 70° F. for 5 hrs., 40° F. for 14 hrs.		Samples stored at 40° F. for 19 hrs.	
	Control.	Cu added 2·6 p.p.m.	Control.	Cu added 2·6 p.p.m.
	Eh	Eh	Eh	Eh
½	·29402	·32291	·30730	·30987
1½	·28795	·33864	·31315	·30721
2½	·27878	·37288	·31262	·30342
4	·25630	·34756	·31226	·30150
5	·25980	·37105	·30420	·29877
6	·26390	·37016	·30337	·39891
19	·15837	·28208	·30242	·43803
Degree of tallowiness after 24 hrs.	...	...	...	+ + + + +

The effect of bacteria in tending to reduce the potential is particularly noticeable in the case of the first set of samples where conditions are favourable for bacterial growth.

Webb & Hileman found that the addition of traces of copper to milk and cream raised the redox potential to about 0.45 volt (31).

Chilson showed that the addition of ascorbic acid to milk prevents the development of oxidised flavour (35).

Brown *et alia* found that feeding greenstuffs, tomato juice, lemon juice or ascorbic acid to the animals, reduced the tendency of milk to develop oxidised flavour (36).

In experiments to test the effect of light Briggs found that, whereas the control experiment gave an "induction period" of 17¼ hours, the experiment in which the fat was exposed to ultra violet light from a mercury arc lamp gave an "induction period" of only 5½ hours (25).

Briggs also reports the following data showing that oxidised fat and lactic acid decrease the duration of the "induction period" whereas curd increases it.

Experiment.	Conc. of Material Added.	Induction Period. (hours)
4 Controls	...	Mean 15½
Oxidised fat	1%	8½
3 Controls	...	Mean 15¾
Lactic acid	0·1%	11¾
3 Controls	...	Mean 17¼
Lactic acid	0 1%	12
Control	...	17¾
Curd added	...	30¾
2 Controls	...	Mean 20½
Curd added	...	32½
Control	...	30
Curd added	...	27¾

As noted by Briggs the curd is partially decomposed at the high temperature of the experiment; its action probably will not be the same at low temperatures.

Kieferle & Senss report that butter wrapping materials may be classed in order of efficiency as protective materials as follows: parchment, cellophane, ultrament, tin or aluminium foil (37). (Ultrament is a proprietary vegetable parchment impregnated with a yellow dye.)

Barnicoat tested various wrapping materials and his report indicates the great superiority of covering materials composed of metal foils waxed to parchment (38). Of transparent cellulose wrapping materials, red coloured material proved best.

Emery and Henley found, when working with lard, that exposure of the fat to air did not in itself produce a rancid condition (39). The presence of a metal catalyst or exposure to light was necessary to produce rancidity.

Coe *et alia* noted a similar light effect (40). When an oil was not exposed to light high peroxide values could be developed without the oil becoming rancid. Such oils which have developed high peroxide values in the absence of light and which have no rancid defect, become rancid upon exposure to light. When cottonseed oil was protected from light the oil did not become rancid even though the peroxide value had reached 200 m. moles per kilo. When not protected from light, rancidity developed when the peroxide value reached 60 m. moles per kilo. Oils which had developed peroxide values of 60 m. moles per kilo or greater in darkness, turned rancid upon exposure to light.

Baumann and Steenbock found that maxima of light absorption occurred at wavelengths of 460 and 485 mμ (41).

THE "CURD" CONTENT OF BUTTER.

The curd content of butter is usually slightly over 1 per cent. The proteins of milk are mainly casein, about 3 per cent., and lactalbumin, about 0.4 to 0.5 per cent. Mitchell and Hamilton quote the following data for the amino acid content of these substances (54).

Although the exact composition of neither material is known exactly, the approximate proportions of the various amino acids are known.

Amino-acid.	Percentage Present in—	
	Casein.	Lactalbumin.
Glycine	0·4	0·4
Alanine	1·8	2·4
Valine	7·9	3·3
Leucine-iso-leucine	9·7	14·0
Aspartic acid	4·1	9·3
Glutamic acid	21·8	12·9
Hydroxy glutamic acid	10·5	10·0
Serine	0·5	1·8
Proline	8·0	3·8
Hydroxy proline	0·2	...
Phenylalanine	3·9	1·2
Tyrosine	6·5	1·9
Cystine	0·3	4·0
Arginine	5·2	3·0
Histidine	2·6	1·5
Lysine	7·6	8·4
Tryptophane	2·2	2·7
Ammonia	1·6	1·3
Total	94·8	81·9

The Decomposition of Proteins in Butter.

It is characteristic of the heterotrophic group of bacteria that they elaborate exo-cellular enzymes which break down proteins into fragments sufficiently small to diffuse into the cell and become available for cellular metabolism. Acids also cause hydrolysis of proteins. Thus, it is found that, as cream and butter age, the percentage of the nitrogen present as amino-nitrogen increases.

One constantly reads of the groups of proteolytic and non-proteolytic organisms and of tests for distinguishing the two types, but it seems reasonable to assume that there are no such hard and fast groups, and that there are all types of organisms ranging from such as only break down small quantities of protein sufficient for their own requirements to those which elaborate large quantities of proteolytic enzymes thus causing amino-acid production far in excess of their actual requirements.

Now the breakdown of the butter proteins to amino-acids produces at least one substance known to have a very strong flavour. This substance is glutamic acid. Glutamic acid is produced commercially by the hydrolysis of gluten with acid and is used as a meat flavour in China and Japan.

Depending upon conditions and the species involved, bacteria may cause further break-down of the protein and produce undesirable substances such as indol. The necessary condition for this activity appears to be lack of available carbohydrate. Lactose, the carbohydrate present in butter, is only present in small quantity, a fraction of a per cent, and is utilised by a comparatively small percentage of species. Thus, it follows that conditions are suitable for extensive protein degradation, particularly by such organisms as are unable to utilise lactose for their energy requirements.

There appears to be confusion among writers regarding the expression "protein sparing effect of carbohydrate." The expression probably originated from the observation that, in the presence of utilisable carbohydrate, such products as indol are not formed. Some workers have demonstrated that in the presence of the carbohydrate there is generally a greater quantity of protein decomposed. There is no doubt about the observations. It appears that the phenomena mentioned are bound up with the type of material used by the organisms for the production of energy. For this purpose utilisable carbohydrate is preferred, in which case a vigorous growth of the organisms takes place, but the extent of the protein degradation is only sufficient to produce substances permeable to the cell membranes, within which it is utilised for building up cell protein. In the absence of utilisable carbohydrate less vigorous growth takes place, but the organisms must draw upon protein matter for energy supply as well as for their anabolic processes. To produce the energy—hydrolyses produced bacteriologically involve small energy changes—break-down of protein in other ways is required with consequent production of noxious substances.

Mitchell and Hamilton cite the following examples of the effect of utilisable carbohydrate upon bacterial metabolism (54).

Organism.	Significant product in protein medium.	Significant change in the carbohydrate protein medium.
Diphtheria bacillus	Sol. diphtheria toxin ...	Lactic acid. No toxin.
Shiga's bacillus	Sol. Shiga toxin	Lactic acid. No toxin.
Bacillus coli	Indol	Lactic acid. No indol.
Bacillus proteus	Sol. proteolytic enzyme ...	Lactic acid. No enzyme.

It should be noted that in the second instance cited in each case, the medium still contains protein. The only difference from the first medium is the addition of utilisable carbohydrate.

In this connection, it is well known that the addition of sugar to cream helps it to retain a sweet clean flavour. This may be due to:—(1) increasing the available carbohydrates and thus altering the bacterial metabolic products; and (2) raising the osmotic pressure of the serum to a value unfavourable for bacterial growth.

Organisms which do not attack carbohydrates probably differ from the above described course in their metabolic activities. The great majority of such organisms do not produce indol, and it follows, therefore, that they do not derive energy by breaking down tryptophane to give indol. However, they may attack one or more of the other amino-acids derived from protein for the purpose of energy production. Organisms behaving in this manner include, for instance, the species contained in the genera Alcaligenes, Brucella and Kurthia (Zopfius).

So far as is known, there are very few organisms which do not attack carbohydrates and which do produce indol. Before concluding that such organisms do not prefer carbohydrate—possibly rare compounds to which their normal habitat has adapted them—as a source of energy, it would be necessary to examine their action on a very large number of carbohydrates.

Let us briefly consider the factors causing protein cleavage. These include enzymes derived from the cream, enzymes derived from the microbial flora, and purely chemical factors including catalysts. All these factors may operate in cream.

However, with modern methods of butter-making, which include the high temperature treatment of cream in pasteurisation and deodorisation in "Vacreators," the effect of the enzymes originally present in the cream can be largely, if not entirely, neglected.

Ferris noted that, as cream decreased in grade, there was an increase in the percentage of nitrogen present as amino-acids and ammonia (55). The following table shows results reported by him.

AMINO-NITROGEN AND AMMONIA AS PER CENT. OF TOTAL NITROGEN, SHOWING RANGE FOR FIRST AND SECOND GRADE CREAMS.

Plant No.	First Grade.		Second Grade.	
	Minimum.	Maximum.	Minimum.	Maximum.
1	1·1	2·0	...	...
2	1·5	2·1	...	...
3	5·5	5·8	...	...
4	5·5	6·9	7·7	9·1
5	6·4	7·7	8·7	9·0
6	7·0	7·1	8·4	9·1
7	6·7	8·0	8·5	8·9
8	6·8	8·0 (8·7)	8·6	...
9	6·5	7·9	8·4	10·5
10	7·3	8·3 (9·4)	8·6	10·5
11	7·0	8·7	11·7	12·2
12	7·5	9·2	11·9	12·2
13	9·0	10·0	11·5	13·3

It will be seen that, in the case of every plant, cream graded second contained a higher percentage of nitrogen present as amino-nitrogen and ammonia. Taking into account the fact that the graders at the various factories will not in general have the same standards for the different grades of cream, it is interesting to note how close agreement was obtained in selecting as first grade, creams which upon analysis were found to contain not more than about 8% of the nitrogen as amino-acids plus ammonia.

Jacobsen studied the relationship between the amino-nitrogen content of cream and the grade (56). His results, whilst not so definite as those obtained by Ferris, are similar. The following table shows data taken from Jacobsen's paper.

AMINO-NITROGEN CONTENT OF CREAM OF THREE GRADES.

Grade.	No. of Churnings.	Description.	Av. amino-N.
1	5	Sweet, clean, below 0·20% acidity	4·82
2	10	Slightly off-flavoured, below 0·60% acidity ...	5·17
3	12	Markedly off-flavoured, above 0·60% acidity or both	6·45

Jacobsen's figures for the range of amino-acid contents of cream samples in each grade is, as with the results obtained by Ferris, fairly wide. This is only to be expected, for the quality of cream may be low because of factors other than decomposition. Jacobsen said: "In general, it may be noted that cream of low acidity showed a low percentage of amino-nitrogen and produced

a butter of high flavour score. Conversely, the high acid cream showed higher amino-nitrogen content and lower butter score. Exceptions, however, will be noted . . . where feed flavours were responsible for the low butter flavour scores received.'' The position may be stated as follows: cream which is low grade because of decomposition has a higher amino-nitrogen content than good cream but, cream may be low grade for reasons other than decomposition; for instance, it may have pronounced feed taints.

The value of any method for grading cream depends on its usefulness in classifying the cream samples according to their potential butter-making quality. It is desirable, therefore, to inquire how closely grading according to soluble-nitrogen content satisfies this criterion. The following table, taken from Jacobsen's paper shows the flavour scores of butter samples made from cream graded on its amino-nitrogen content.

Per cent. amino-N.	No. of Churnings.	Butter flavour Scores.	
		Range.	Average.
<5%	7	33—38	35·9
5–6	12	34—37	35·3
>6	8	31—34	32·2

From the table it will be noted that: ''Cream containing more than 6% of the total nitrogen as amino-nitrogen made butter of significantly lower flavour score. Cream of lower amino-nitrogen content showed considerable variation.''

Rahn *et alia* noted that, the poorer the quality of butter at the end of the storage period, the greater the increase in the amino-nitrogen which had taken place (57).

Hunziker & Spitzer found that the increase of soluble nitrogen compounds in butter held in cold storage was closely related to the quality of the butter (as shown by the flavour score) when it went into store and also at the end of the storage period (58).

The following table shows the increase in one of the soluble nitrogen fractions accompanying a given change of score in the exhibition samples at the U.S.A. Dairy Show in 1926. The figures were obtained by Spitzer and Parfitt (59).

Change in Score.	No. of Samples.	Increase in N. not precip. by Phosphotungstic Acid.
		%
Increased	6	0·62
Loss of 0·5 point	6	0·71
Loss of 1·0 point	5	0·82
Loss of 1·5 point or more ..	6	0·97

THE LECITHIN CONTENT OF BUTTER.

The phospholipid content of milk and of various milk products has been determined recently by Holm *et alia* (60). Results reported are as follows:—

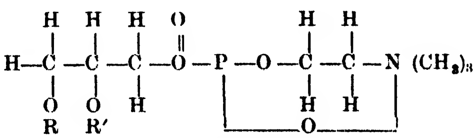
Whole milk	0.0337%
Skim milk	0.0169%
Cream (41% fat)	0.1816%
Butter	0.1819%
Buttermilk	0.1872%

During the butter-making process the phospholipid content was found to be distributed as follows:—

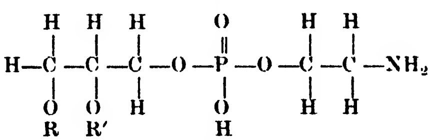
Whole milk (fat 3.88%)	100.0%
Skim milk	45.28%
Cream	52.30%
Buttermilk	28.34%
Butter	24.73%

The above figures are calculated from the organic phosphorus content of the various materials assuming a phosphorus content of 4% for the phospholipid fraction. The assumption of the phosphorus content given is based upon the work of Kurtz *et alia* (61). The assumption that the relative proportions of the constituents of the phospholipid fraction remains constant in the milk and various milk products may not be correct, but likely variations will not alter the above figures greatly.

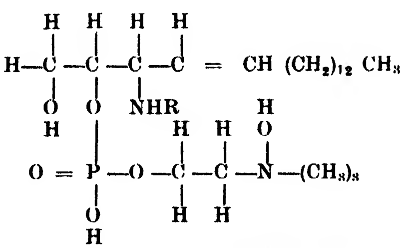
Kurtz *et alia* found the ratio of the constituents in the phospholipid fraction of milk to be lecithin: cephalin: sphingomyelin as 8.4 : 4.5 : 1. The constituents have the following formulae:—



LECITHIN.



CEPHALIN.



SPHINGOMYELIN.

The symbols R. and R′ in the formulae represent fatty acid groups. Analysis of the lecithin-cephalin fraction indicated the fatty acid content to be: myristic acid 5.2%, stearic acid 16.1%, arachidic acid 1.8%, oleic acid 70.6%, dicostetrenoic acid (?) 6.3%. The acids of the cephalin-sphingomyelin fraction are comprised almost entirely of lignoceric acid.

Although vague statements are made regarding the effect of proteins as stabilisers of the milk emulsion, it would appear that the stabilisation is largely, if not entirely due to the lecithin. The emulsion is not destroyed by pasteurisation, which process would be expected to break-down the emulsion if it were stabilised by proteins. The emulsifying properties of lecithin are well known;

commercially, preparations of lecithin derived from soy beans are used for stabilising emulsions. The difficulty of separating lecithin from butterfat has long been noted (13). Thurston *et alia* describe experiments of cream washing to obtain pure butterfat (51): "Lot 2 cream was converted into washed butterfat in order to remove from the butterfat the substances absorbed on the fat globules. The cream was diluted to a volume of about 3 gallons with water at approximately 100°F., separated by means of a De Lavel No. 17 separator, rediluted, and separated until the cream had been washed 14 times or more. Near the end of this procedure a noticeable oiling-off of the butterfat occurred, which indicated that the fat globules no longer were stabilised. Further washing caused a complete oiling-off of the butterfat."

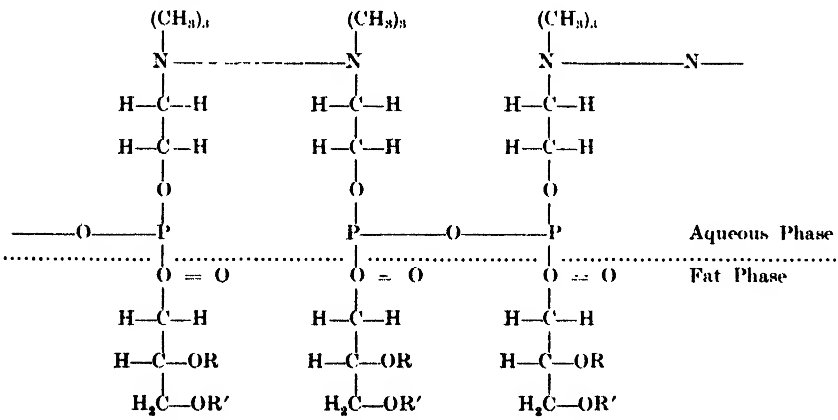
The writer has found that commercial lecithin is a satisfactory material to employ for the re-emulsification of low grade butter prior to renovation. For a small churning the process is carried out as follows:—

The contents of ten 56 lb. cases of butter are broken up and warmed with 56 gallons of water. A small quantity of melted fat is skimmed off the material in the vat and used to dissolve the emulsifying material, 2½ lbs. of commercial material containing 60-65% lecithin.

The lecithin solution is then spread as evenly as possible over the surface of the fat and gently mixed into the fat layer. Beaters are started and when an even mixture is formed in the vat the material is passed through the "vacreator."

The butter emulsion leaves the latter apparatus as a stable emulsion which may be churned in the usual manner as when churning fresh cream.

The writer conceives a monomolecular (?) film at the surface of the fat globules, arranged somewhat along the following lines, as probably forming the important stabilising membrane.



However, a protein is also closely adsorbed on the fat globules (62).

THE DECOMPOSITION OF LECITHIN AND ITS EFFECT UPON THE QUALITY OF BUTTER.

A perusal of the literature indicates that certain butter defects probably have a common origin. These defects are: a sensation of oiliness to the palate, metallic flavours and fishy flavours. This point has certainly been noted since

1909 when Sommerfeld reported that the oily taste of butter is often accompanied by a fishy taste (63). Rogers pointed out in 1914 that fishiness may be preceded by an oily or a metallic flavour (64, 65). Washburn & Dahlberg found there was a tendency for the development of the defects called metallic flavour, an oily sensation to the palate, and a fishy flavour in sequence (5). Some of the results reported by the latter workers in this respect will be noted later.

It is well known that the fishy flavour of herring and mackerel brines is largely contributed by the substance trimethylamine, $N(CH_3)_3$. This substance might be produced from lecithin by decomposition of the chlorine group, $(CH_3)_3 N(OH) CH_2 CH_2 OH$. If trimethylamine is the cause of the taint in fishy-flavoured butter, the substance should cause the defect when worked into fresh clean-flavoured butter. The experiment was carried out by Supplee (6). He added trimethylamine and a number of its compounds (lactate, butyrate, oleate, stearate, the mixture of compounds formed with the insoluble fatty acids from butter, and the mixture of compounds formed with the soluble fatty acids from butter) to butter to give a concentration not exceeding 85 p.p.m. of butter. The review of his experiments says: "While there are several conflicting opinions as to the presence of the fishy flavour in any particular sample, it is nevertheless evident that the greatest number of positive comments is found in the samples containing trimethylamine in one form or another. It will also be noticed that usually the greatest uniformity of such comments is found in the samples containing trimethylamine in unstable form. This is particularly true as to the samples to which trimethylamine was added alone, in combination with butyric acid, or in combination with the mixed soluble fatty acids of butter. These results are in harmony with the volatility, the taste and the odour of the compounds in pure state. The lack, in a few instances, of a majority opinion with regard to the samples containing trimethylamine oleate, trimethylamine stearate, and trimethylamine with the mixed insoluble acids, might be explained on the basis that, since these substances are so extremely unstable, the trimethylamine had nearly all volatilized before the time of scoring." A table from Supplee's paper has been reproduced in the section dealing with the effect of salt upon the flavour of butter.

Sommer and Smit also tried the effect of working trimethylamine into butter (1). These workers incorporated trimethylamine lactate into butter to give a concentration of 100 p.p.m. and then submitted the material to judges and laymen for criticsm: it was described as fishy by all.

If trimethylamine is the cause of the fishy taint in butter it should be possible to separate it from fishy-tainted samples but not from fresh, clean flavoured samples. This has been achieved by Sommer and Smit (1). The following data is reported by them:—

Sample No.	Description of Sample.	Trimethylamine.
1	Fresh butter	None
2	Fresh butter	None
3	Fishy butter. Commercial Sample No. 1	32·65 p.p.m. 32·45 „
4	Fishy butter. Commercial Sample No. 2	22·37 „ 22·37 „
5	Fishy butter. Sample of experimental butter furnished by Hunziker	35·97 „ 35·52 „
6	Fishy butter. Experimental butter containing 0·4% acid and 0·1% iron lactate	23·72 „ 23·80 „
7	Fishy butter. Experimental butter containing 0·6% acid and 0·1% iron lactate	25·2 „ 25·1 „

The assumption that trimethylamine is the product involved considered together with the assumption that lecithin is the substance forming the stabilising membrane, will explain why the various defects mentioned above may occur about the same time or alone. Decomposition of the lecithin would gradually break down the emulsion giving rise firstly to a cold metallic sensation and later to an oily sensation. If the choline fraction were so far disintegrated as to free the trimethylamine, fishy flavours would develop, but, if it were not decomposed to give trimethylamine, such a flavour would not be produced.

The assumption that trimethylamine derived from lecithin is the cause, in most instances, of fishy flavour of butter, however, does not preclude the possibility of such a flavour being due to other causes in some instances.

It is well known that butter stored near materials having strong aromas, such as fruit, will readily absorb such aromas. Oliver attributed fishy defects in butter to storage near fish (66).

The effects of some feeds upon the flavour of milk is well known. Lewkowitsch (67) and other writers state that the trouble may be caused by feeding fish meal.

Kirchner stated that a fishy defect may be caused by feeding oil cakes (68). Linseed oil-cake feeding is fairly common practice, and the fat of this material contains appreciable quantities of linolenic acid. The work of Hill and Palmer, previously mentioned, indicates that highly unsaturated glycerides from linseed oil are secreted in the milk of cows fed with the oil (22). Hydrolysis of the fat of butter made from such milk would probably free linolenic acid along with other glycerides. Linolenic acid has a fishy odour (15, 69).

Work at the Stockholm University indicated a correlation between high iodine values for the butterfat and the development of fishy flavours in the butter (21). High iodine values were found for the butterfat of cows fed on large quantities of young leguminous crops. Here again, a similar explanation to the last suggests itself: or possibly the explanation may be as in the next instance.

Cows fed large quantities of sugar beet waste are prone to yield milk with a fishy taint. Such waste contains betaine in appreciable quantities and Davies has found that the main metabolite of this substance in the cow is trimethylamine oxide (71).

Betaine　　　　Trimethylamine oxide

Davies found that diffusion of the latter compound readily takes place between the milk in the udder and the blood stream (72). It appears, therefore, as though the fishy flavoured milk produced by cows fed on quantities of beet waste is almost certainly due to the secretion of trimethylamine oxide in the milk.

Sommer and Smit, from their review of the literature, concluded that there was a very general agreement regarding the factors that favour the development of fishiness in butter (1). These factors are: a high acidity in the cream; a high salt content of the butter; overworking in the manufacture of the butter; and metallic contamination of the butter. To verify these conclusions they conducted the following experiment:—

Sweet cream, 400 lbs., was divided into ten lots of 40 lbs. each as follows:—

Lot 1.—Raw, unripened.
Lot 2.—Raw, naturally ripened, acidity 0.4%.

Lot 3.—Raw, naturally ripened, acidity 0·6%.
Lot 4.—Raw, naturally ripened, acidity 0·6%, neutralised to 0·25%.
Lot 5.—Pasteurised, unripened.
Lot 6.—Pasteurised, starter ripened, acidity 0·4%.
Lot 7.—Pasteurised, starter ripened, acidity 0.6%.
Lot 8.—Pasteurised, starter ripened, acidity 0·6%, neutralised to 0·25%.
Lot 9.—Pasteurised after natural ripening to 0.4% acidity.
Lot 10.—Pasteurised after natural ripening to 0.6% acidity.

Unfortunately, the workers did not make up another lot in which the acidity was obtained by the addition of pure lactic acid.

All obvious precautions were taken in the butter making such as working in an earthenware hand churn and avoiding contact with metal surfaces.

The butter made from each of the ten lots of cream was divided into seven parts which were treated as follows:—

Part 1.—Unsalted.
Part 2.—Medium salted, 1·5% salt.
Part 3.—Highly salted, 3·0% salt.
Part 4.—Highly salted, 3·0% salt, plus 0·1% ferric oxide.
Part 5.—Highly salted, 3·0% salt, plus 0·1% iron lactate.
Part 6.—Highly salted, 3.0% salt, plus 0·1% tin lactate.
Part 7.—Highly salted, 3·0% salt and overworked.

Each of the seven parts prepared from each of the ten lots of cream was divided into two parts; one of these was stored at -10°F., the other was stored at 35-40°F. The samples were scored by three judges at intervals of about a month and the different flavours carefully noted. For results see Table A.

From the results obtained Sommer and Smit drew the following conclusions:—

"1. Fishiness appeared earlier and more often in the samples stored at the higher temperature.

2. True fishiness was found practically only in the unpasteurised samples (lots 1, 2, 3 and 4).

3. Pasteurisation after ripening (lots 9 and 10) seemed to be more effective in preventing fishiness than pasteurisation before ripening (lots 5, 6, 7 and 8). Lots 6 and 7, pasteurised and then ripened, showed fishiness in the samples containing 3.0% salt and iron lactate, while the corresponding lots, lots 9 and 10, pasteurised after ripening, showed no signs of fishiness.

4. The high acid samples, lots 2 and 3 especially, developed fishiness most rapidly.

5. None of the unsalted and low salted samples developed fishiness.

6. Only one of the samples where acidity and salt alone were active developed a slightly fishy odour.

7. The presence of iron oxide and iron lactate combined with high acid and salt caused the most distinct and greatest number of fishy samples. The iron lactate was more active than iron oxide.

8. Tin lactate did not cause fishiness.

9. Overworking showed a slight tendency to aid the development of fishiness.

10. Neutralisation to a low acidity before churning was effective in reducing fishiness. Lots 4 and 8, neutralised to 0.25% acid, showed less fishiness than the corresponding unneutralised samples, lots 3 and 7.

"Thus the results of these experiments clearly show that high acid, high salt and oxidation produced by overworking, but more especially by the aid of catalysers, are the important factors in the development of fishiness. The results also show that pasteurisation and neutralisation are effective means of checking fishiness."

Let us review the experiments mentioned in Tables A and B. In the first place it seems quite obvious that the presence of salt up to 3 per cent., with or without acid up to 0.6 per cent., in the absence of other factors, does not result in breakdown of the lecithin to give trimethylamine. In the case of the samples made from cream lot 3, enzymic decomposition was possible, and further, a large number of samples containing both high acid and high salt contents did not develop fishiness.

TABLE A.

FLAVOURS DEVELOPED IN THE EXPERIMENTAL BUTTER AT 35 TO 40° F.

Lot number.	Months storage.	Treatment of the Butter.						
		Unsalted.	1·5% salt.	3·0% salt.	3·0% salt plus 0·1% ferric oxide.	3·0% salt plus 0·1% iron lactate.	3·0% salt plus 0·1% tin lactate.	3·0% salt plus overworking
1	4	..	Slightly oily	Slightly oily	Metallic	Oily	Slightly oily	Slightly oily
	6	..	Slightly oily	Slightly oily	Metallic and oily	Slightly fishy	Slightly oily	Slightly oily
	8		Slightly oily	Oily	Slightly fishy	Fishy	Oily	Oily
2	4		Slightly oily	Oily	Slightly fishy	Fishy		Oily
	6	.	Slightly oily	Oily	Fishy	Very fishy		Slightly fishy
	8		Slightly oily	Very oily	Fishy	Very fishy		Oily and fishy
3	4	. .		Very oily	Slightly fishy	Very fishy		Very oily
	6			Very oily	Fishy	Very fishy		Fishy
	8			Slightly fishy	Fishy	Very fishy		Oily and fishy
4	4			Slightly oily	Oily	Very oily		Oily
	6			Slightly oily	Oily	Fishy		Oily
	8		.	Oily	Tallowy	Fishy and tallowy		Oily
5	4		Oily	Oily	Oily	Oily		Oily
	6	.	Oily	Oily	Oily	Very oily		Oily
	8		Oily	Oily	Tallowy	Fishy	Oily	Very oily
6	4		.		Oily	Metallic and oily		Oily
	6				Oily	Slightly fishy		Oily
	8			.	Tallowy	Tallowy		Very oily
7	4				Oily	Oily		Oily
	6	..			Oily	Slightly fishy		Oily
	8	.			Very oily	Tallowy		Very oily
8	4	..			Oily	Metallic and oily		Slightly oily
	6	. .			Oily	Oily		Slightly oily
	8	.			Oily and tallowy	Tallowy		Tallowy
9	4	.. .	.	Slightly oily	Metallic	Very metallic		Slightly oily
	6	..		Slightly oily	Oily	Metallic and oily		Slightly oily
	8	..		Oily	Oily	Tallowy		Oily
10	4	..		. . .	Oily	Metallic and oily		Oily
	6	. . .	.	....	Oily	Oily		Oily
	8	. . .	.	Oily	Oily and tallowy	Tallowy		Very oily

TABLE B.

FLAVOURS DEVELOPED IN THE EXPERIMENTAL BUTTER AT 10° F.

Lot number.	Months storage.	Treatment of the Butter.						
		Unsalted.	1·5% salt.	3·0% salt.	3·0% salt plus 0·1% ferric oxide.	3·0% salt plus 0·1% iron lactate.	3·0% salt plus 0·1% tin lactate.	3·0% salt and overworking.
1	4	..	..	...	Metallic and oily	Metallic and oily	...	....
	6	...	...	Oily	Very oily	Oily and fishy	.	Oily
	8	..	..	Oily	Fishy and tallowy	Fishy and tallowy	..	Oily
2	4	...	.	.	Oily	Very oily		..
	6	..	Slightly oily	Oily	Slightly fishy	Fishy	.	Oily
	8	.	Slightly oily	Very oily	Fishy and tallowy	Fishy and tallowy	..	Very oily
3	4	...		Oily	Metallic and oily	Very oily	Oily	..
	6	..	Oily	Oily	Slightly fishy	Fishy	Oily	Oily
	8	..	Oily	Oily and tallowy	Fishy and tallowy	Fishy and tallowy	Oily	Very oily
4	4	...			Metallic and oily	Metallic and oily		
	6	.	.	Oily	Metallic and oily	Metallic and oily		Oily
	8	.	.	Oily	Oily and tallowy	Tallowy		Oily
5	4	.			Metallic	Metallic and oily		.
	6	.	..	Slightly oily	Slightly oily	Oily		Oily
	8	.	.	Oily	Tallowy	Tallowy		Oily
6	4	..		Oily	Metallic and oily	Oily		.
	6	..		Oily	Very oily	Slightly fishy	.	Oily
	8	.		Very oily	Tallowy	Fishy and tallowy		Very oily
7	4		.	Oily	Metallic and oily	Oily		.
	6		..	Oily	Very oily	Slightly fishy	Slightly oily	Oily
	8	.		Very oily	Tallowy	Fishy and tallowy	Oily	Oily
8	4	.	..	Oily	Metallic	Oily	Slightly oily	.
	6	..	.	Oily	Oily	Oily	Slightly oily	Slightly oily
	8	..		Oily	Tallowy	Tallowy	Oily	Oily
9	4	..	..	Oily	Oily	Oily		..
	6	..	.	Oily	Very oily	Very oily		Oily
	8	...	...	Oily	Tallowy	Tallowy		Very oily
10	4	....		Oily	Oily	Oily		
	6	..	...	Oily	Very oily	Very oily	.	Oily
	8	....	....	Very oily	Tallowy	Tallowy		Very oily

The experiments do not indicate whether the presence of salt is necessary, in addition to such factors as enzymes and metallic contamination, to produce the fishiness. However, O'Callaghan stated that much Australian unsalted butter was criticised as fishy when it arrived in London (73). Washburn and Dahlberg noted in their experiments that fishiness could develop in unsalted butter (5). The experiments of Supplee also indicate that fishiness develops in unsalted butter (6).

The experiments of Sommer and Smit, noted above, indicate that high acidity is not necessary for the development of fishiness (lots 1, 4 and 5). For two of these lots the acidity is not given: in one case the cream was sweet, however, and in the other case the butter was made from cream neutralised to 0.25 per cent. acidity. Included in the paper by Supplee is data for a number of samples prepared from cream having acidity as low as 0.16 per cent. which went fishy during storage (6).

However, notwithstanding the fact that salt and acidity are unnecessary for the development of fishiness in butter during storage, there is a general consensus of opinion that the defect is more often noted in the presence of such factors. This is shown in the review of the literature by Sommer and Smit (1).

In the first place, as previously mentioned, the presence of acid and salt will make more evident a defect which otherwise might have passed unnoticed.

However, experiments indicate that both acid and salt favour the development of fishness. The following data from the work of Washburn and Dahlberg illustrate the effect of salt (5):—

Churn No.	Salt.	Judge's Comments on the Butter.			
		Initial.	113th Day.	284th Day.	304th Day.
3	% 0	Good	Trifle mouldy, cheesy	Slightly unclean, metallic	Weak body, bitter, curdy.
	1·72	Will not go fishy	Metallic . .	Slightly oily, slightly fishy	Fishy.
2	0	Good	Trifle rancid	Slightly fishy, slightly unclean	Fishy, overworked, body poor.
	2·07	Tendency to fishy	Metallic	Slightly oily, slightly fishy	Fishy.
6	0	.. ....	Metallic .	Slightly oily, slightly fishy	Weak body, fishy.
	2·41	. . ..	Fishy . .	Fishy, coarse ..	Fishy, overworked, body poor.
1	0	Dry	Rancid, metallic	Metallic, cheesy, slightly unclean	Fishy, overworked, body poor.
	2·51	Tendency to fishy	Fishy . . .	Fishy, slightly unclean	Fishy, bad.
4	0	Good ..	Metallic, old flavour	Fishy	Weak body, overworked, slightly fishy.
	3·27	Good	Metallic	Fishy ...	Fishy.
5	0	Extra fine aroma	Slightly metallic	Good aroma, slightly oily	Flat storage flavour, weak body.
	3·79	....	Coarse, not fishy	Coarse, unclean ..	Fishy.

Butter samples prepared from cream ripened to an acidity of 0.58 per cent. were stored for 284 days at —15°F. and for a further 20 days at 58°-60°F. Salted and unsalted samples were prepared from each churning. Unfortunately, salt was not added to the unsalted samples at the time of tasting and possibly, had this been done, fishiness would have been detected in both members of a pair where it was only noted in one member (the salted sample) in the results as reported. Sommer and Smit said:—"However, besides this intensifying effect of the salt," on the flavour, "it must also be involved in the actual production of the flavour, because fishiness is not produced by simply incorporating salt into an unsalted sample of butter, the corresponding salted sample of which has become fishy in storage." No relevant data regarding this statement were presented.

In view of the effect of salt in controlling deterioration when the material is held at room temperature, which will be mentioned later, it is important to note that salt, in itself, has not been shown to cause deterioration in cold storage.

The following statement of Rogers *et alia* regarding the effect of acidity is characteristic (74):—"In a tabulation of the examination of 259 samples of experimental butter from cream of known acidity, of 137 samples from cream having an acidity below 0.3 per cent. only 2, or 1.5 per cent., were marked 'fishy,' while of 122 samples having an acidity of 0.3 per cent. or over, 60, or 49.2 per cent., were fishy."

Rogers and Gray presented the following data showing the effect of acidity in causing deterioration (75) :—

THE INFLUENCE OF DIFFERENT ACIDS ON THE FLAVOUR OF BUTTER.

Lot.	Acid added.	Acidity of Cream.	Score after 15 days.
		%	
1a	None ...	0·144	88—Trifle unclean and very greasy.
1b	Lactic ...	0·216	88—Trifle unclean and very greasy.
1c	Lactic ...	0·432	86—Fishy and greasy.
2a	None ...	0·126	90—Trifle oily, body weak and greasy.
2b	Acetic ...	0·216	87—Very greasy, rancid and fishy odour.
2c	Acetic ...	0·350	84—Very fishy and greasy.
3a	None ...	0·126	90—Clean but greasy.
3b	Hydrochloric	0·225	90—Trifle unclean and oily.
3c	Hydrochloric	0·450	84—Very fishy, greasy.

In these experiments the samples were not all brought to the same acidity at the time of examination, and, in view of the effect of acidity on the flavour of butter, are therefore open to criticism.

In the study of butter deterioration at least three factors must be given consideration. These are:

(1) The growth of bacteria with the liberation of bacterial exo-cellular enzymes.

(2) Deterioration produced by the bacterial enzymes, and

(3) Deterioration due to purely chemical factors.

In general, at low storage temperatures where the growth of micro-organisms is mainly inhibited and the deterioration is probably mainly due to chemical factors (as appears to be the case with the development of fishiness), one would expect the greatest deterioration in the most acid material—due to such effects as increased activity of metallic impurities.

Wiley reported the following data showing the effect of acid in causing deterioration of unsalted butter (76).

	Method of Manufacture.	Loss on Storage (points).		
		16 Weeks at 40° F.	18 Weeks at 14° F.	18 Weeks at 0° F.
1	Sweet cream	2·6	1·1	1·1
2	Sweet cream neutralised to pH 7·3	2·55	0·75	0·75
3	Ripened to pH 6	1·7	2·3	2·0
4	Lactic acid added to pH 6	3·7	1·5	1·6
5	Ripened to pH 5	3·6	2·0	2·3
6	Lactic acid added to pH 5	5·3	0·8	0·55
7	Ripened to pH 6 and neutralised	2·3	1·1	1·1
8	Ripened to pH 5 and neutralised	1·7	0·5	0·4

In the first place, the results of Wiley are not comparable with those of Rogers and Gray because his material was unsalted. Further, Rogers and Gray noted the effect of acidity on the development of the specific defect called fishiness,

but the type of deterioration in Wiley's samples was different, the samples turning stale, cheesy, rancid or fruity. Wiley's results are mentioned because they show the effect of different factors.

Let us consider experiments Nos. 1, 3 and 4. When stored at 40° F. at which temperature the growth of bacteria is likely to be marked, the products of the lactic fermentation have apparently repressed microbial growth and the loss of grade was less than in the case of the unripened sample. Pure lactic acid does not appear to be the main bacterial product responsible for checking the growth of the organisms and when added to cream accelerated chemical decomposition. At the lower temperatures of storage the growth of organisms will be checked and chemical deterioration will be the notable effect. Thus it will be seen that the addition of lactic acid slightly increased the deterioration. In the case of the ripened sample the deterioration was still more marked presumably because of the effect of the acid and of bacterial enzymes produced during the ripening process.

To return to the subject of lecithin decomposition, Sommer and Smit made experiments to determine the effect of acid and salt in causing breakdown of an emulsion of this substance (1). Mercuric chloride was used to prevent bacterial decomposition The samples were kept in an incubator adjusted to 28°C. for three weeks. The following data resulted:—

THE CHEMICAL DECOMPOSITION OF LECITHIN INTO TRIMETHYLAMINE.

Treatment of Sample.	0·1% Lecithin plus:				
	Nothing.	0·1% Ferrous Lactate.	H_2O_2 1 cc. to 14 cc.	Oxygen.	0·1% Ferrous Lactate plus O_2.
	Per cent. Trimethylamine of total possible.				
No salt, no acid	1·89	1·46	2·49	2·16	2·50
2% salt, no acid	2·85	1·66	5·77	2·85	4·65
4% salt, no acid	2·85	2·50	5·77	2·85	4·99
No salt, 0·25% lactic acid	4·22	3·32	8·79	6·55	6·60
No salt, 0·50% lactic acid	4·48	4·32	10·34	10·52	7·93
2% salt, 0·25% lactic acid	5·60	4·98	11·29	14·65	8·43
4% salt, 0·25% lactic acid	5·60	5·77	11·20	14·82	8·13
2% salt, 0·50% lactic acid	5·77	7·41	13·78	17·23	8·87
4% salt, 0·50% lactic acid	6·29	7·41	14·04	17·75	9·13

"Note: The amount of lecithin, ferrous lactate, salt and acid are expressed on the basis of butter (16% moisture) corresponding to these emulsions, *i.e.*, the actual concentration of these substances in the emulsions is 6¼ times as great as stated in the table."

"The results given show that lecithin will undergo decomposition and yield trimethylamine under conditions that exclude bacterial action. This decomposition takes place most readily under conditions that combine salt, high acid and oxidation. These results correlate very nicely with the conditions known to favour the development of fishiness, and thus lend support to the theory that the fishy flavour results from the chemical decomposition of lecithin yielding trimethylamine."

In explaining the effect of salt and acid in accelerating the decomposition of lecithin, Sommer and Smit note:—

1. Salt solutions dissolve lecithin;
2. Salt lowers the freezing point of brine; and
3. The addition of salt to butter necessitates additional working of the butter, a factor favouring oxidation.

Acid conditions favour the decomposition of lecithin because:

1. Acids accelerate hydrolysis,
2. Acidity aids oxidation; and
3. Acids in the cream cause the absorption of metals during the manufacturing process.

The writer would point out that probably the main effect of the acid brine is to activate the metals because of the high ionic activity; further, concerning butter made from high acid cream, it is probably the action of microbial pro-oxidative enzymes which causes the defect, an explanation which agrees with the findings that pasteurisation of such creams generally stops the development of the defect.

Attempts to produce a fishy flavour in butter by bacterial inoculation have led to conflicting results.

Reakes, Cuddie and Reid found that plugs of fishy butter inserted into clean butter did not cause fishiness to be developed in the clean butter (77).

Rogers in surveys of creameries where outbreaks of fishy butter had been noted found no unusual species of bacteria in the products and was unable to produce fishiness in cream by inoculating it with bacteria isolated at such creameries (75).

Supplee was able to produce fishy butter from cream that had been ripened 24 hours after inoculation with B. *ichthyosmius* or a certain unnamed organism (6).

Cusick also was able to produce fishy taint butter from cream ripened after addition of B. *ichthyosmius* (79).

Sommer and Smit studied the two organisms used by Supplee (1). They found that the two organisms could produce trimethylamine from lecithin given suitable conditions, but the organisms failed to grow in conditions that are favourable for the development of fishiness,*i.e.*, salt and acid conditions. They consider that the investigators who claim to have produced fishiness in butter by means of bacteria either did not exclude the factors that lead to chemical decomposition of lecithin, or they produced the defect in quite abnormal conditions.

The writer, however, cannot agree with the opinions of Sommer and Smit. As explained above, salt and acidity in the absence of other factors do not cause fishiness. The organisms studied by Supplee and Cusick may, during their growth in the cream, have produced enzymes capable of causing the necessary type of lecithin decomposition. As the cream was not heat treated, such enzymes would remain active in the butter even though development of the organisms was inhibited.

THE MICROBIOLOGICAL EXAMINATION OF BUTTER.

The same two methods which are used for the determination of the numbers of bacteria in milk samples may also be used for determining the numbers of bacteria in butter samples. These are the "direct count" method and the "plate count" method.

The "direct count" method was adapted to the examination of butter samples by Hammer & Nelson (87). Fay has also described a suitable technique (88).

The "direct count" method has but limited use in the examination of butter because many of the organisms to be seen are dead. In the case of pasteurised butter prepared from sour cream or cream which has been ripened with starter, this is particularly so.

Most of the plate counts of bacteria present in butter samples recorded in the literature are probably far too low. This is especially to be expected when the counts were made upon beef-extract agar, a medium far different in com-

position from butter, the medium in which the organisms have been growing. Counts made on whey-agar media can be expected to be more reliable. However, even with these med.a, care would be necessary in selecting the milk for its preparation, as milk drawn from animals suffering from mastitis can be expected to contain inhibitory chemical substances. Probably media of the type recently suggested for making counts of the organisms in milk will eventually be generally used for butter work (89, 90).

The following portion of a summary, abstracted from the report by Wilson *et alia,* will serve to show the limitations of the "plate count" (89):

"Ostensibly it measures the numbers of bacteria in milk, but in fact it does not. On account of the difference between various species of bacteria in their nutritional, respiratory, and temperature requirements, on account of the fact that many organisms may be dead, and, most important of all, on account of the gross irregularity in the distribution and clumping of the organisms in the milk, the plate count merely registers the number of bacterial units capable of multiplying under the particular conditions selected. Since the average number of bacteria per clump is variable from one milk to another, and from time to time in the same milk, and since these clumps may disintegrate to a quite uncontrollable extent during the process of dilution, it follows that the figures yielded by the plate count are arbitrary, not strictly comparable from milk to milk, merely approximate, and have no real significance.

"The technique is complex, is difficult to standardise, and requires highly-skilled workers. Even under favourable conditions, with the method standardised as far as possible, the experimental error is very large, and on any one count an allowance of ± 90% may have to be made. Even this margin of error will not include all results . . . . . ."

The above criticism, although written in connection with the bacteriological grading of milk, is applicable almost word for word to the examination of butter samples.

However, notwithstanding the factors noted in the above criticism, the plate count shows a surprisingly high correlation coefficient when compared with the "individual direct count" (at the moment milk is again being considered) and, in the present state of our knowledge, the individual direct count must be accepted as giving the closest estimation of the total numbers of organisms in milk samples. To quote from the "Standard Methods of Milk Analysis" (91):—"As it is only in this way that counts of bacteria themselves can be made, it must be recognised that accurately made microscopic counts of individual bacteria give the truest picture of the actual number of bacteria in raw milk that can be obtained with any technique."

Robertson & Frayer report the following data showing the relationship between the "agar plate count" and the "individual microscopic count" (104).

Temp. of Expt.	No. of Samples.	No. of obs.	Co-eff. of Correlation.	Standard Deviation.
80° F.	17	139	+ ·90	± log. 1·42
70° F.	17	228	+ ·93	± log. 1·37
60° F.	17	353	+ ·94	± log. 1·37
50° F.	10	302	+ ·94	± log. 1·30

It must be admitted that, so far as milk count work is concerned, when "plate counts" are correlated with "individual direct counts," the standard deviation is very high; the mean standard deviation in the above table is ± log 1.37.

To consider the application of the "plate count" to butter deterioration studies, the standard deviation in any series of experiments can be expected to be less than that above. The reasons are as follows:—

(1) The "direct count" takes into consideration all organisms, alive or dead, and, in the case of butter deterioration, we are concerned only with the living organisms.

(2) Instead of having to satisfy the nutritional requirements of all the organisms present, it is only necessary to supply the requirements of organisms capable of developing in butter.

We can conclude that, when a fair number of samples of butter are examined by the "plate count" method a high degree of correlation may be expected between the mean counts obtained and the number of organisms capable of developing in the butter. Individual counts, however, may be far from correct.

For the purpose of shortening the time of incubation, "microscopic colony counts" have been suggested. In connection with butter work, Johns has described such a method for the determination of the numbers of yeasts and moulds in butter (96). Recently, Moir and Russell have described such methods for both yeast and mould counts and for bacterial counts (97). The above criticism of the "plate count" method is generally applicable to the "microscopic colony count" method.

(*To be continued.*)

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Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

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Butter: Its Composition and Deterioration.

(Continued.)

H. H. KRETCHMAR, Dairy Bacteriologist.

THE GROWTH OF MICRO-ORGANISMS IN BUTTER AND THE EFFECT OF THE COMPOSITION OF THE BUTTER AND OF STORAGE CONDITIONS.

If one takes into consideration all the conditions affecting the experiments, it will be found that but little reliable data is available regarding the effect of any single controlling factor on the growth of one type of organism. Let us enquire how this comes about.

In the first place it should be noted that the so-called "bacteria counts" are counts of bacteria plus percentages, generally undetermined, of yeasts and possibly moulds. Media used for the enumeration of the numbers of bacteria do not inhibit the growth of yeasts and moulds and, unless separate counts are made simultaneously of the numbers of these latter, one cannot say to what extent they contribute to the total count. Grimes and Hennerty, in their study of the quantitative changes in the microbiological flora of sweet-cream salted butter stored at 15°F., noted that in many cases the yeasts had so far increased as to make it impossible to obtain bacterial counts (70).

In the case of yeast and mould counts, it is only since the work of Hood and White that the conditions for obtaining true yeast and mould counts have been recognised (80, 81). They found that media for the enumeration of yeasts and moulds in butter should have the acidity adjusted to pH 3.5 and the plates should be incubated for 5 days at a temperature of 25°C. In consequence of the lack of appreciation of these conditions most of the work on the growth of yeasts and moulds is unreliable the counts in many cases being probably largely comprised of acid-tolerant bacteria.

The Growth of Moulds in Butter.

Macy studied the influence of various factors upon the growth of moulds in butter (82). The factors affecting growth which are controllable by the buttermaker are salt and temperature, and the effect of these factors will be particularly noted. Macy reviews a great deal of literature on this subject, but only a few pertinent cases will be mentioned here.

Gripenberg found that moulds (*Penicillium sp.* and *Trichosporium sp.*) would grow in butter serum containing 18% and 20% of salt for as long as 5 to 6 months (83). When the serum was diluted growth was much better. He made hanging-drop preparations of butter serum containing 0, 10 and 25% salt and inoculated them with *Penicillium crustaceum* and *Trichosporium collae*. In the unsalted serum growth was active after 9 days for both types; with 10% salt the growth was slight; with 25% salt no growth was evident.

Fettick prepared sterile butter samples containing 0, 0.5, 1, 2, 3, 4, 5 and 6 per cent. salt (84). Series of these samples were inoculated with the moulds *O. lactis*, *Mucor mucedo* and *P. glaucum* and stored for one week in a dark place at 17°C. The growth of all three species decreased with increase in the percentage of salt, and no growth appeared in samples containing 4% or more salt. He also followed the growth of *O. lactis* and *P. glaucum* in unsalted butter and in butter containing 3% salt. In the salted butter the moulds decreased immediately and disappeared within 2 months; in the unsalted material they increased steadily.

Boeckhout and de Vries studied the growth at 21°C. of *Hormodendrum sp.* in butter containing 0, 2, 2.5 and 3 per cent. salt (85). Growth only occurred in the unsalted butter.

Macy carried out experiments to determine the effect of the salt content of butter upon the growth of moulds (82). The following table shows the results obtained when the moulds were inoculated directly into butter and the butter stored for six weeks at 10°C. in a humid atmosphere.

EFFECT OF SALT UPON THE GROWTH OF MOULD CULTURES IN STERILE BUTTER.

Time	1 Week				3 Weeks.				6 Weeks.			
Per cent. salt	0	1·2	2·6	2·9	0	1·2	2·6	2·9	0	1·2	2·6	2·9
Per cent. salt in brine	0	7·1	13·9	15·3	0	7·1	13·9	15·3	0	7·1	13·9	15·3
Culture												
Alt. humicola		−	−	−	+	−	−	−	++++	++	+	+
A. flavus	−	−	−		−	−		−	−		−	−
A. niger	−	−	−	−	−	−	−	−	−	−	−	−
H. cladosporioides	−	−	−	−	+	−	−	−	+++	++	+	+
M. sylvaticus	−	−	−	−	−	−	−		+	+	−	−
O. lactis var. A.	−	−	−	−	−	−	−	−	−	−	−	−
O. lactis var. B.	−	−	−	−	−	−	−		−	−	−	−
P. biforme	+	−	−	−	++	+	−	−	++++	++	++	++
P. expansum	+	−	−	−	++	+	−	−	+++	++	++	++
R. nigricans	−	−	−	−			−	−	+	−	−	−
Check		−	−	−	−	−	−	−	−	−	−	−

The moulds studied were species isolated from butter samples.

From his review of the literature Macy notes that:—"In a general way it appears evident that low temperatures impede the development of moulds in butter but experimental evidence for different species and specific temperatures is lacking. Butter has been found to be mouldy even at relatively low temperatures when stored for sufficient periods of time."

That temperature has a marked effect upon microbiological growth is well known, and moulds are no exception to this rule. Macy carried out experiments to verify the effect of temperature particularly in the case of mould growth in butter (82). The following table shows Macy's results when the moulds studied were inoculated into sterile sweet cream, incubated for four days at 20°-25° C., and the cream made into butter. Representative data only is selected.

EFFECT OF TEMPERATURE UPON THE GROWTH OF MOULD CULTURES IN BUTTER MADE FROM INOCULATED CREAM.

	Per cent. salt.	Extent of growth, high humidity, after—								
		2 Weeks.			4 Weeks.			6 Weeks.		
Temperature °C.:		20°.	10°.	0°.	20°.	10°.	0°.	20°.	10°.	0°.
Culture— *Alt. humicola*	0	—	—	—	—	—	—	—	—	—
	1·5	—	—	—	—	—	—	—	—	—
A. flavus	0	+	—	—	+ +	—	—	+ +	—	—
	1·4	+ +	—	—	+ + +	—	—	+ + +	—	—
	2·2	+ + +	—	·	+ + +	—	—	+ + +	—	—
	4·0	+ +	—	·	+ +	—	—	+ +	—	—
A. niger	0	+	—		+	—	—	+	—	—
	1·5	+ +	—	—	+ + +	—	—	+ + +	—	—
	2·5	+ +	—	—	+ +	—	—	+ +	—	—
	4·5	+ +	—	—	+ +	—	—	+ +	—	—
H. cladosporioides	0	+ + +	+ +	+	+ + +	+ + +	+ +	+ · —	+ + + +	+ +
	1·6	+ +	+ +	—	+ +	+	+	+ +	+	+
	2·7	+ +	+	·	+	+	—	+	+	—
	3·3	+	+ +	—	+	+	—	+	+	—
M. sylvaticus	0	+ +	—	—	+ +	—	·	+ —	—	—
	1·1	·	—	—	—	—	·	—	—	—
O. lactis var. A.	0	·	—	—	—	—	·	—	—	—
	1·4	—	·	—	—	—	—	—	—	—
P. biforme	0	+	+	+	+	+ +	+ +	+	+ +	+ +
	0·7		+	—	—	+ +	—	—	+ +	+
	2·3	+		—	+	+ +	—	·	+ +	—
	3·1	+	·	—	+	—		·	—	—
P. expansum	0	+ +	·	—	+ +	+ +	—	+ +	+ +	—
	1·3	+ +	+	—	+ +	+ +	—	+ +	+ +	—
	2·2	+ +	·	—	+ +	+ +	—	+ +	+ +	—
	3·0	+	+	—	+	+ +	—	+	+ +	—
R. nigricans	0	—	—	—	—	—	·	·	—	—
	1·3	—	—	—	—	—	—	—	—	—

Macy's discussion of his results with salt and temperature in general reads: "The amount of salt in butter is unquestionably an important factor influencing the growth of moulds. The results presented in the foregoing pages demonstrate that the effect of salt upon growth depends especially upon the species of moulds, the amount of moisture, and the temperature. In accordance with many previous investigations, *O. lactis* was checked by a slight concentration of sodium chloride in the substrate. The disappearance of this fungus in salted butter may be explained on this basis. The species of *Mucor and Rhizopus* studied were only slightly more resistant to salt and consequently would not be expected to be important in the moulding of salted butter. *Aspergillus niger* and *Aspergillus flavus* are resistant to high salt concentrations, but when butter was kept at temperatures below 10°C. growth was impeded. For this reason, their importance as causes of moulding in butter stored at the usual commercial temperatures is slight. The other moulds studied—*Alternaria*, *Hormodendrum*, and *Penicillium*—were found to be capable of growing in high salt concentrations and at the lower temperatures. As these species produce the most marked changes in the appearance, flavour, and aroma of butter when they are able to develop, they are of major importance. The species of *Alternaria* and *Hormodendrum* studied produced dark green, almost black, smudgy areas. Their mycelia spread considerable distances from the point of infection, both along the surface and to considerable depths in the butter. The species of *Penicillium*

used did not mar the appearance of butter particularly, although in some cases sufficient green fruiting bodies were formed to give a slight, dusty discolouration of the surface. The cultures of *Penicillium* affected largely the flavour and aroma. Butters in which these species were growing became distinctly cheesy in flavour and odour, and in these characters suggested Roquefort cheese. In any consideration of the effect of salt on the growth of mould in butter, the concentration of the salt in the droplets of water within the butter must be taken into account. Even though a gravimetric analysis of butter may indicate a high salt content, it is important to know how much water is present to carry this salt. Some of the experiments reported in the preceding pages illustrate this point. If the percentages of water and salt are both high, the concentration of salt in the water may not be any higher than if both are low. Equally, if the water content is low and the salt content moderately high, the brine may be highly concentrated. Then, also, the salt may be unevenly distributed in the minute droplets of moisture within the butter. Some may represent a strong and others a weak brine. The number of conidia in butter, even under extreme conditions, will seldom be large and never considerable in proportion to the number of water droplets. It is conceivable that a conidium may be allocated to a droplet of water containing little or no salt and an abundant supply of food and accordingly be able to germinate and develop without restraint. Only one such instance would lead to serious consequences as far as moulding is concerned. Thus the effect of salt on the growth of mould on butter will depend entirely upon the relative concentration of the salt in the droplets in which the mould spores, or mycelium, may be located. This may partly explain the moulding of salted butter, even though the composition of the butter and type of mould may at first have been considered sufficient reasons for expecting protection against such a contingency."

The following table is taken from an earlier paper by Macy (86). It shows data for mould counts secured on 2,700 lots of butter of varying composition, age and quality and from many creameries, taken at random from 60 lb. tubs as they were shipped to the market.

RELATION OF MOULD COUNTS TO SALT CONTENT OF BRINE.

Salt Content of Brine.	Distribution of Mould Counts in each Group.			
	10 or less.	11 to 50.	51 to 100.	101 or more.
%	%	%	%	%
Unsalted	7·0	6·1	8·0	78·9
0·4— 7·9	30·5	21·7	8·7	39·1
8·0— 8·9	42·2	44·4	6·7	6·7
9·0— 9·9	46·9	33·3	10·4	9·4
10·0—10·9	47·2	34·7	6·8	11·3
11·0—11·9	44·0	42·0	8·2	5·8
12·0—12·9	51·3	36·6	5·8	6·3
13·0—13·9	47·7	33·0	7·9	5·4
14·0—14·9	53·4	35·6	6·4	4·6
15·0—15·9	53·9	35·3	6·0	4·8
16·0—16·9	57·7	34·0	3·6	4·7
17·0—17·9	48·5	38·2	5·9	7·4
18·0—18·9	63·9	16·7	16·7	2·7
19·0—26·9	59·1	36·4	0·0	4·5

Macy has noted a factor worthy of consideration in the packing of butter (82). This is that all the moulds which he studied, and which may be considered fairly representative of the types commonly found in butter, will not grow in the absence of air. In view of this fact it is desirable that butter be wrapped in paper impervious to air and with the paper in the closest possible contact with the butter, so that surface moulding of the butter may be minimised. Macy also noted that a humid atmosphere was essential for growth. In no case studied did moulds grow on the surface of butter when the humidity of the atmosphere was as low as 70-75%. Here again the value of an impervious wrapper in contact with the surface of the butter is indicated.

The Growth of Bacteria in Butter.

According to its concentration in solution, salt may exert either a stimulating or an inhibitory action upon the growth of bacteria. At 0.5 molar concentration it exerts a stimulating effect upon bacterial growth, but at 3 molar concentration it exerts an inhibitory effect. (0.5 molar solution contains 2.93 gms. sodium chloride in 100 mls., 3 molar solution contains 17.55 gms. sodium chloride in 100 mls.)

Salt also widens the range of pH values of media within which bacteria will grow. The following data showing the beneficial effects of low concentrations of salt upon the growth of *B. coli* is cited by Topley & Wilson (92).

Media.	pH Value.	Turbidity Appears (in hrs.).
Peptone water	5·3	36
Peptone water, 0·2 molar NaCl	5·3	4
Peptone water	8·3	7
Peptone water, 0 2 molar NaCl	8 3	3½
Peptone water	4·8	No growth
Peptone water, 0·2 molar NaCl	4 8	20

An industrial fermentation where the effect of salt upon microbial growth has been well studied is the pickling of cucumbers or gherkins. When the fruits are received at the pickling factories they are covered with a very varied microbial flora. Before pickling takes place the only preparation given them is, perhaps, a preliminary washing to remove the greater part of the adhering soil and dust. They are then transferred to the pickling vats. The pickling brine, being made from rough salt and fresh water, also contains, initially, a very varied microbial flora. The end to be achieved is a selective growth of the lactobacilli present on the fruit to produce a clean conversion of the carbohydrates of the fruit to lactic acid

The selective growth of the lactobacilli is achieved by careful adjustment of the salt content of the brine. The concentration of the brine must be maintained at 10.5% salt if the growth of putrefactive organisms is to be prevented and the growth of the lactobacilli permitted.

If it is necessary to store the fruit in the brined condition when the fermentation has been completed, the salt concentration of the brine is increased to 16% to prevent all further bacterial growth.

In butter containing 16% moisture the salt contents, to bring the concentration in the serum to the above figures, will be 1.7% and 2.6% respectively.

In the case of the specific defect known as "surface taint" of butter in America, and which is similar to, if not identical with, the defect known as "rabbit-O" in Australia, Derby & Hammer found that a salt content of 1.5% in butter having a moisture content of 13.2% prevents the development of the defect (93). In butter containing 16% moisture the equivalent salt content is 1.82% to give the same brine concentration of 11.36%.

From a survey of the literature it may be seen that the influence of salt on the keeping quality of butter varies according to the temperature of storage. When the butter is stored at temperatures which permit microbial growth, the effect of salt in restraining growth is important. When held at temperatures which tend to inhibit bacterial growth, the effect of salt is of less importance, and, in fact, because the salt enhances all flavours, including undesirable flavours, and because salt in the presence of other factors may accelerate chemical decomposition as explained previously, the keeping quality of salted butter may be inferior to the keeping quality of the same butter unsalted. However, it is a fact that butter after sale is quite generally held at temperatures which permit microbial growth, and furthermore, it has been pointed out previously that salt itself is not a cause of butter deterioration. It follows, therefore, that a knowledge of the correct percentage of salt which should be added to butter to obtain satisfactory inhibition of microbial growth is most important.

A number of reports are available indicating the effect of salt upon the "total microbial count" of butter (sometimes wrongly called "total bacterial count").

The following data is taken from a paper by Spitzer and Parfitt (59). The data was obtained by examination of 183 samples of butter submitted for competition and held in cold store for approximately three months.

The effect of salt upon the per cent. of butters increasing in numbers of micro-organisms during storage.

Per cent. salt in brines	0–5	5.1–10	10.1 15	15.1–20
"Total bacteria" ..	70.00	67.01	48.55	15.79

The following data is taken from a paper by Macy (94). The samples were stored in most varied conditions.

THE EFFECT OF SALT CONTENT ON CHANGE IN "BACTERIAL" COUNT DURING STORAGE OF BUTTER.

Salt Content.	Total Samples.	Change of "Bacterial" Count.		
		Increased.	No Change.	Decreased.
		%	%	%
0·0	62	72·1	0·0	27·9
0·4—0·95	123	17·7	0·0	82·3
1·0—1·9	207	27·5	0·5	72·0
2·0—3·4	213	26·3	1·9	71·8

The following data is taken from the work of Washburn & Dahlberg (5). Samples of butter prepared from ripened cream were stored at -15°F. for 284 days and for a further 20 days at 58-60°F. A salted sample and an unsalted sample were prepared from each churning.

Churn Number.	Per cent. Salt.	"Bacteria" in thousands per cc.			
		Initially.	113 days at —15° C.	284 days at —15° C.	284 days at —15° C., 20 days at 56–60° C.
3	0	3,756	100	280	2,880
	1·72	3,248	360	560	96
2	0	944	28	164	2,000
	2·07	3,984	376	108	48
6	0	10,560	26	176	1,600
	2·41	3,464	54	272	10
1	0	...	320	448	5,280
	2·51		672	...	4
4	0	5,466	44	52	1,360
	3·27	70[illegible]	52	224	17
5	0	9,862	240	432	2,560
	3·79	2,250	456	2,320	144

The data illustrates the generally accepted opinion that the organisms die off more rapidly in unsalted than in salted butter when the butter is stored at low temperatures, and also the inhibiting effect of salt upon microbial growth when the material is held at temperatures which do not inhibit bacterial growth.

Consistent with the fact that salt inhibits growth when other conditions are suitable for the growth of bacteria in butter, is the increased deterioration which takes place in unsalted material. The effect of salt in inhibiting the production of "surface taint" has already been mentioned. The most common defects in unsalted butter are probably the "cheesy" odours and flavours. The work of Herreid *et alia* indicates that such defects are developed in unsalted butter because of the action of micro-organisms (3). To consider a more recent publication, Jacobsen noted that the flavour deterioration was more rapid in unsalted butter held at 21°C after storage at —25°C, than in salted butter similarly treated (95).

Attempts have been made to correlate the types of organisms present in butter with the grade of cream from which the butter was made and with the deterioration taking place during storage.

Hedrick made experiments to determine the extent of the correlation between the organisms found microscopically in the butter serum and the grade of cream from which the butter was made (98). 524 butter samples were studied, 143 prepared from excellent cream, 125 from good cream, 159 from fair cream, and 97 from poor grade cream. The percentages in each group correctly correlated with the grade of cream were 91.6 per cent., 58.4 per cent., 42.7 per cent., and 53.6 per cent. respectively. This seems to indicate that the microscopic examination was fairly accurate in distinguishing butter made from excellent cream, but for lower grades it was not a reliable method. The presence of "starter" organisms or holding the samples for as long as 30 days did not materially alter the percentage graded correctly. (It is necessary to note that the butter was salted and that therefore little bacterial growth would be expected in storage).

"The two apparent reasons for not being able to determine the 'good,' 'fair' and 'poor' grades as accurately as the 'excellent' were:—

(1) Low scoring cream was not always the result of bacteriological action but was caused by chemical action and absorbed feed flavours.

(2) The other reason was the contamination by organisms subsequent to pasteurisation of cream and during the churning process."

Examination of Hedrick's data shows that of the number of samples which were wrongly graded many were misplaced by only one grade. Unfortunately, he has not shown how accurate the grading would have been had butter samples prepared from cream graded low because of feed taints been excluded. Had this been done it seems likely that the conclusion reached would have been that certain bacteriological pictures can be associated with low grade cream only if the poor quality is due to bacterial decomposition.

Nelson studied the flora found microscopically with a view to predicting the keeping quality of butter when stored for 21 days at 21°C (99). He found that clumps of well-stained thin rods were generally a sure sign that deterioration would take place, particularly in the case of unsalted butters. He was able to predict the keeping quality correctly in 96.4 per cent. of the commercial, salted samples; in 79.6 per cent. of unsalted and 84.9 per cent. of the exhibition butter samples.

Flake and Parfitt found that "there was a limited relation between the microscopic picture and the decrease in score (100). In general, it was found that large numbers of rod-shaped organisms were found in butter having poor keeping quality." The butter, which was salted, was stored for 10 days at 15.5°C.

It has long been known that some species of organisms hydrolyse fat; other species produce extensive protein decomposition. A search of the literature gives no conclusive evidence that the numbers of either lipolytic or caseolytic organisms can be correlated with butter deterioration. It seems to the writer that the extent to which any species is undersirable, taking, for instance, caseolytic species, will be dependent upon its ability to grow in the conditions obtaining in the butter and upon the nature of the protein decomposition products which it produces, and not merely upon its ability to break down protein in an unspecified manner. Also it seems highly probable that the extent to which a lipolytic specie will be undesirable in butter will be dependent upon the nature of the products formed and its adaptability to conditions in the butter. Certainly the proposed tests for caseolytic and lipolytic species give no indication of the adaptability of the organisms to the conditions in butter or the type of decomposition products which they produce.

In connection with tests for lipolytic species, the remarks made by the writer previously in connection with the flavours and odours of the fatty acids should be remembered.

Stark & Scheib studied a large number of proteolytic and caseolytic species of bacteria isolated from butter (101). They concluded: "Those groups occurring in numbers large enough to be of probable significance in the spoilage of butter were Gram-negative rods, Gram-negative micrococci, Gram-positive sarcinae, and Gram-positive non-spore-producing rods. In butters supporting the growth of large numbers of bacteria, only the Gram-negative rods were regularly present in large enough numbers to be of importance in the spoilage of all the butters tested."

Guthrie *et alia*, as a result of their experiments, concluded: "In the absence of other spoilage factors, a direct correlation seems to exist between the number of fat-splitting and casein-digesting bacteria and the keeping quality of the butter" (102). Their data does not seem to bear out this statement.

Flake & Parfitt presented the following data in connection with samples of salted butter made from sour cream which were stored for 10 days at 15.5°C. (100).

RELATION OF PROTEOLYTIC BACTERIAL COUNT TO DROP IN SCORE OF BUTTER HELD FOR 10 DAYS AT 15·5° C.

	Drop in Score (points).							
	0	1	1·5	2	2·5	3	3·5	4 or >
Number of Samples ..	22	9	18	22	8	12	4	6
Log. av. of proteolytic counts .	9,250	2,350	5,000	31,000	23,000	7,500	4,000	32,000
Prot counts of 100,000 or more.%	4·5	11·0	5·6	36·4	50·0	16·7	25·0	50·0

RELATION OF LIPOLYTIC COUNT ON TRIBUTYRIN MEDIUM TO DROP IN SCORE OF BUTTER HELD FOR 10 DAYS AT 15·5° C

	Drop in Score (points).							
	0	1	1·5	2	2·5	3	3·5	4 or >
Number of Samples	16	6	9	10	5	9	3	5
Log av. of counts	120,000	150,000	130,000	890,000	480,000	590,000	1,350,000	680,000

RELATION OF LIPOLYTIC COUNT ON NILE-BLUE-SULPHATE MEDIUM TO DROP IN SCORE OF BUTTER HELD FOR 10 DAYS AT 15·5° C.

	Drop in Score (points).							
	0	1	1·5	2	2·5	3	3 5	4 or >
Number of samples	22	9	17	22	9	12	4	...
Log. av. of counts	7,400	9,200	21,500	117,500	17,000	38,000	26,000	2,050

The workers concluded that: "There was a marked relation between high proteolytic counts on tryptone-skim milk agar and poor keeping quality.

"A marked relation was found between high lipolytic counts on tributyrin medium and poor keeping quality. This relationship was less marked when nile-blue-sulphate medium was used."

The writer fails to see the relationship in any of the above tables.

Jacobsen found large numbers of lipolytic and proteolytic bacteria were present in certain of his samples of unsalted butter after holding at room temperature, but no definite correlation could be noted between the growth of these types of bacteria and the development of flavour defects (95).

No work of a convincing nature appears to have been reported to show that proteolytic or lipolytic counts are related to the keeping quality of butter. To show whether any such relation exists samples of butter should be prepared, divided, and preservative added to one part of each sample. If the difference between the deterioration in the normal portions and the preserved control portions—both portions being kept in identical conditions—could be correlated with the numbers of any type of organism, then one would be justified in assuming that deterioration was due to the type of organisms studied.

The Growth of Yeasts in Butter.

Because the acidity of media for the detection of yeasts and moulds has, in the earlier work, not been satisfactorily standardised, reliable data showing the effect of salt on the growth of yeasts in butter is not available.

It is proposed to show some data reported in the literature as yeast counts, but which it would be more correct to regard merely as counts of the acid-tolerant flora, including yeasts and indefinite numbers of acid-tolerant bacteria.

The following data is taken from a paper by Macy (86).

RELATION OF YEAST COUNTS TO SALT CONTENT OF BRINE.

Salt Content of Brine (per cent.).	Distribution of Yeast Counts in each Group.			
	10 or less.	11 to 50.	51 to 100.	101 or more.
Unsalted	28·1	14·0	16·7	41·2
0·4— 7·9	34·8	8·7	8·7	47·8
8·0— 8·9	24·4	17·8	26·6	31·2
9·0— 9·9	19·8	33·3	13·6	33 3
10·0—10·9	27·3	33·5	15·3	23·9
11·0—11·9	22·6	41·2	17·7	18·5
12·0—12·9	18·7	40·0	19·6	21·7
13·0—13·9	26·6	38·7	15·5	19·2
14·0—14·9	30·2	40·4	14·2	15·2
15·0—15·9	33·6	42·5	11·4	12·5
16·0—16·9	33·9	45·3	10·7	10·1
17·0—17·9	41·2	48·5	7·4	2·9
18·0—18·9	47·2	41 7	5·6	5·5
19·0—26·9	36·4	63·6	0·0	0·0

The data was obtained for "yeast counts" on 2,700 lots of butter of varying composition, age and quality, and made in many creameries. The samples were taken at random from 60 lb. tubs of butter as they were shipped to the market. The counts were made on whey-agar medium acidified with 1 cc. of 1% sterile tartaric acid solution at the time of plating.

The following data was reported by Macy (94). The samples were stored in very varied conditions.

THE EFFECT OF SALT ON THE CHANGE IN "YEAST" COUNT DURING STORAGE OF BUTTER.

Salt Content.	Total Samples.	Change of "Yeast" Count.		
		Increased.	No Change.	Decreased.
0·0	62	71·4	3·4	25·2
0·4—0·95	123	38·7	1·6	59·7
1·0—1·9	207	33·3	4·9	61·8
2·0—3·4	213	29·1	6·6	64·3

Spitzer & Parfitt presented the following data (59). It was obtained by examination of 183 samples of butter submitted for competition and held in cold store for approximately three months.

The effect of salt upon the per cent. of butters increasing in numbers of micro-organisms during storage.

Per cent. salt in brines	0–5	5.1–10	10.1–15	15.1–20
Yeast counts	40.000	48.62	21.42	5.26

From the above information it must be concluded that accurate data regarding the effect of conditions upon the various types of microbial growth in butter is lacking. However, sufficient data is available with regard to the effect of salt

to indicate the necessity of carefully controlling the salt content of butter. The growth of many species of organisms is inhibited when the concentration of salt in the butter serum is about 10.5% and the growth of most species is inhibited when the concentration is raised to 16%. With butter containing 16% moisture, the salt contents of the butter to give these concentrations of salt in the serum are 1.7% and 2.6% respectively.

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*Original paper not seen.

ERRATA.

Volume 17 No. 1, March, 1940.

Page 107, line 12, read "were" for "was."

Page 111, last paragraph, line 5, read "the" for "with."

Page 134, paragraph 2, line 3, insert "viable" between "of" and "organisms," and delete "capable of developing."

Soil Erosion.

Report of the Soil Conservation Committee on the incidence of soil erosion in the agricultural areas of Western Australia within the 12-25 inch rainfall belt.

The matter of soil conservation and the control of the ravages of soil erosion has received the attention of public authorities in many parts of the world.

In Australia soil erosion and conservation methods were considered by the Conference of the Commonwealth and State Ministers held in Adelaide, August 26th to 29th, 1936, when it was decided to request all State Governments in the Commonwealth to form Soil Erosion and Conservation Committees to co-ordinate the work in the Commonwealth. All State Governments have given effect to this decision and in New South Wales, in addition, a Soil Conservation Service has been formed.

The Western Australian committee was constituted as a Soil Erosion Committee by the Hon. Minister for Agriculture, Mr. F. J. S. Wise, on December 22nd, 1936. This committee was later enlarged and reorganised as a Soil Conservation Committee and now consists of the following Government officers: the Conservator of Forests, Mr. S. L. Kessell, chairman; the Surveyor-General, Mr. W. V. Fyfe; the Superintendent of Wheat Farming, Mr. I. Thomas; the Officer in Charge of Irrigation, Mr. A. R. C. Clifton; the Superintendent of Horticulture, Mr. H. R. Powell; the Superintendent of Dairying, Mr. G. K. Baron-Hay; a representative of the Agricultural Bank, Mr. C. P. Murray; the Plant Nutrition Officer, Dr. L. J. H. Teakle, secretary.

Reports of soil erosion have already been published by the New South Wales, Victorian* and South Australian† authorities and this report is designed to summarise the progress as a result of the work of the Soil Conservation Committee in Western Australia.

At its first meetings the committee considered the incidence of soil erosion problems throughout the whole State. Reports were obtained from field officers of Government departments in outlying districts to supplement the personal observations of members of the committee. As a result of this preliminary survey, it was decided to direct attention for the time being to the agricultural areas lying between the 12 and 25 inch isohyets. The absence of high mountain ranges in the extreme South-West, coupled with the fact that the important catchment areas are State forests, greatly minimizes any danger from widespread water erosion in this region.

In the drier pastoral areas which occupy a large proportion of the State, a few tracts of country are suffering severely from wind erosion following long periods of drought, but the State is fortunate in that the soils in pastoral areas for the most part are types not liable to extensive drift.

Following the decision to concentrate attention first on erosion problems in the wheat-farming and mixed-farming areas of the 12-25 inch rainfall belt, a printed form of questionnaire was distributed to some 664 farmers nominated by 55 road boards, and the balance of this report deals exclusively with this region.

The questionnaire was sent out in March, 1939, and the bulk of the replies was received over the winter months. Occasional replies are still coming in. Of the 664 questionnaires despatched, some 373 returns have been received. One

* Report of Committee appointed to investigate erosion in Victoria.
† Report of Soil Conservation Committee, South Australia, 1938.

road board, Gnowangerup, returned 12 out of the 12 questionnaires submitted, while one, Plantagenet, returned none. On an average, 6 to 9 returns were furnished from each road board where the farmers appeared to be interested in the question of soil erosion.

Many farmers submitted collateral evidence in the form of an attached statement (some 126 of these were received) and, in a number of instances, photos, plans and sketches were enclosed to illustrate answers.

A collateral problem resulting in land deterioration which appears to be causing more concern among farmers is that of soil salinity; some 33 drew special attention to the problem of soil salinity and many of these expressed concern at salt encroachment as affecting their own properties and neighbouring farms in their districts.

The Replies.

The replies have been carefully studied and an endeavour made to obtain farmers' views and assess the position from the farmers' viewpoints. It must be realised that expert inspection may have given a somewhat different picture but in the absence of that service, it is necessary to rely on the replies of farmers. There is no doubt that the replies are sufficiently accurate for a general survey with respect to soil erosion, as the majority of replies show that, generally, the farmers submitting returns had a very keen appreciation of this problem and its implications. There is no doubt that these farmers have accumulated accurate knowledge concerning the conditions leading to soil erosion as a result of observations on their own farms and are appreciative of the need for control; in fact, in many instances control measures, more or less successful, have been applied on their own initiative.

The replies indicate that it is generally conceded that soil erosion is due to faulty management and conservation will be achieved largely as a result of the proper adaptation of soil management, use of wind breaks and proper cultural and cropping methods under the prevailing conditions.

In order to obtain an intelligible picture of the incidence of water and wind erosion, the situation with respect to erosion, as reported by each farmer, has been graded into 5 classes:—

1. None obvious.
2. Very slight, less than 1 per cent. estimated damage.
3. Slight, 1 to 5 per cent. damage.
4. Moderate, 5 to 15 per cent. damage.
5. Severe, over 15 per cent. damage.

It is to be noted that very few reported a severe incidence of soil erosion.

These classes are not related to any published in the literature, but were adopted as a convenient means for interpretation in a general way of the replies received. They should be considered according to the definition and not according to any preconceived ideas from surveys in other places. In this connection attention may be drawn to the contrast with the situation in the United States of America where about 100,000,000 acres of once fertile land have been essentially ruined for practical cultivation by erosion and where the degree of erosion is indicated by similar terms but used in a different sense (in this case with respect to sheet erosion by water action). For instance, in the report on soil erosion in Iowa* the term *slight* refers to areas from which less than 25 per cent of the

* "Soil Erosion in Iowa" Special Report No. 2, April, 1936, of Soils subsection, Iowa Agricultural Experiment Station and Soil Conservation Service, U.S.D.A. co-operating.

surface soil has been removed, *moderate* to areas from which 25 to 50 per cent of the surface soil has been removed and *severe* to areas from which more than 75 per cent. of the surface soil has been removed and the subsoil has been carried away in many instances.

In Western Australia, while soil erosion has not yet reached serious proportions in the agricultural areas, it is of widespread occurrence and, in many instances, is on the increase. To avoid such serious consequences of faulty land management, it is necessary for farmers in this State to take immediate steps to organise their farming operations to prevent the progressive action of the forces of erosion and to effect reclamation of those areas already damaged.

The Incidence of Soil Erosion.

The replies indicate that soil erosion, due to wind and water action, is widespread throughout the agricultural areas. Generally the damage which has resulted is slight but the reports leave no doubt that soil erosion is on the increase in many instances.

Table 1 shows a grading of the replies according to the classes given above.

TABLE 1.

Incidence of Soil Erosion in Western Australia as indicated by the replies submitted by farmers to the questionnaire circulated by the Soil Conservation Committee.

Type of Erosion.	—	Severity of Soil Erosion.					
		None.	Very Slight.	Slight.	Moderate.	Severe.	Total.
Water ...	No. of Replies	116	107	116	28	6	373
	Per cent.	31·1	28 7	31·1	7·5	1 6	100·0
Wind ...	No. of Replies	119	90	[illegible]	66	15	373
	Per cent.	31.9	24.1	22.3	17.7	4.0	100.0

A survey of the replies to the question concerning the course of soil erosion is summarised in Table 2.

TABLE 2.

The course of Soil Erosion on farms in Western Australia.

Type of Erosion.	—	Course of Soil Erosion.				
		Improving.	Stationary.	Slight Increase.	Moderate to Rapid Increase.	Total.
Water ...	No. of Replies	2	69	131	46	248
	Per cent.	1	28	53	18	100
Wind ...	No. of Replies	2	108	95	37	242
	Per cent.	1	45	39	15	100

General Comments.

In the course of the replies, a number of important points were made by farmers and these are summarised as follows:—

1. *Water Erosion.*—Water erosion is essentially a problem of the hilly portions of the districts receiving over 15-inch annual rainfall, and generally shows within 5 to 15 years of clearing. In some instances it is reported that water erosion has appeared earlier and in other instances a longer period has elapsed before water erosion has become apparent. It is recognised as due primarily to improper farming methods and that improved farm management will minimise the damage, and, perhaps, result in improvement in the future. The value of a pasture period or a forage crop lightly grazed, in controlling soil erosion, is well recognised. The damage occurs chiefly on fallow or newly cultivated land after heavy summer or early winter rains. Wet winters also promote water erosion. All types of country are affected where the land is sloping or where there is run-off from catchment areas.

Once soil erosion commences, it increases rapidly for a number of years but often reaches a limit and thereafter remains stationary or improvement sets in. This may be due to changed methods of management on the affected areas.

There is some evidence of sheet erosion, but the damage is caused mainly by gully erosion. Gully erosion does not cause damage to extensive areas, but results in great inconvenience due to the cutting up of paddocks into irregular shaped areas unsuitable for the use of modern machinery. Many farmers regard the gutters as of some value for improving drainage conditions in the cultivated paddocks; there is no doubt that these gullies remove rapidly a considerable amount of excess water which accumulates during the winter months, but it seems likely that a similar benefit may be obtained without the inconvenience of irregular gutters cut haphazardly in the field if some attention to the control of run-off water were given at the outset.

Generally cultivation is the fore-runner of water erosion. A commencement is frequently made where wheeled vehicles are driven up slopes under cultivated conditions. Ploughing out corner headlands is a frequent origin of gully formation and working up and down long slops promotes run-off and losses of soil. Gullies very frequently commence at gates or along sheep pads where they run up and down slopes. Salt patches commonly form the source of a gully, or the commencement of an eroded area.

Control measures generally suggested involve improved farm management and pasture establishment. A number of farmers report having adopted a long rotation with particular attention to the pasture period where the rainfall is more suitable for mixed farming. More judicious cropping, contour working and the use of contour banks on long, steep slopes have been suggested as means of minimising, if not eliminating, the damage from water erosion. Burning of stubbles should not be followed as a general practice on account of the promotion of run-off. Farmers realise, of course, that heavy floods, particularly in the summer time, will always cause a certain amount of damage, but consider that the above control measures will minimise that damage.

Where gullies have been established the use of stones, boughs, straw and rubbish to form dams assists in reclamation, but frequently little benefit is reported as new breaks occur in subsequent wet periods. This points, of course, to the need for the judicious use of contour banks in such instances. Fallows should be left rough where liable to erosion and corners should not be ploughed out if on slopes which may accumulate water.

One farmer illustrated by means of a diagram the use of small banks to prevent the run of water along sheep pads. Some farmers advise leaving the valleys uncleared in order to prevent the formation of gullies in these valleys.

Regarding implements, there seems to be a diversity of opinion. A number of people feel that the mouldboard plough leaves the surface too smooth and recommend the scarifier as a more suitable implement to leave a desirable, rough surface where water erosion is liable. Others hold different views.

2. *Wind Erosion.*—Farmers who are experiencing wind erosion are practically unanimous in pointing to the run of dry seasons as the underlying cause for the increased incidence of this problem in the last four years. They also feel that, with the advent of better rainfall years, the manifestations will largely disappear.

Soil types most severely affected by wind erosion are:—

(a) Loose sandy types such as pear (*Xylomelum angustifolium*) and sandy mallee country.
(b) Snuffy morrel country.
(c) Red sandy loams on sedimentary formations in the Yuna and Yandanooka areas.

Occasionally wind erosion occurs on heavy clay flats where drought has led to the breaking down of the soil structure.

It is reported that damage observed is chiefly of the nature of drifts interfering with fences and other improvements. There has apparently been little loss in yield or productivity, except in a few cases.

It is generally conceded that the advent of wind erosion has been increased by excessive clearing, over-stocking, depredations of grasshoppers and rabbits, over-cultivation to produce a fine surface mulch and like causes. On many farms large areas have been cleared on a face and even the timber along the roads has been destroyed in order to allow crops to grow right up to boundaries. Stubble burning has also accelerated wind erosion. It is commonly observed that wind erosion is most apparent during the fallow period, particularly if the fallow is worked to a fine tilth.

In discussing the control measures, farmers have pointed to the need for timber belts and have recommended that, as far as possible, 2-chain roads should be surveyed in agricultural areas and steps taken to preserve the timber along these roads. Many farmers are looking for means which will render the establishment of timber belts possible at low cost. One farmer claims that he has doubled the growth of grass on one area as a result of establishing a strip of 1,000 pines and is naturally enthusiastic about this means of protecting the soil

Loose, sandy types of soil which will not produce consistent crops should not be brought under cultivation and, on all types liable to wind erosion, some vegetation cover should be maintained throughout the year to limit the action of the wind. Some farmers mention the value of cropping to oats or rye and light stocking to protect the surface. At Irwin, 100 per cent. control of a severe wind erosion problem has been obtained as a result of the use of blue lupins combined with judicious stock management. Subterranean clover has proved beneficial in some of the wetter areas as at Glentromie.

There is no consistency in the opinions regarding the effect of stock, particularly sheep, on wind erosion. Some people have found that pulverising the soil as a result of stocking may accelerate erosion, while others feel that the compacting action is beneficial. Rabbits, in destroying the vegetation cover, are a menace.

Wind erosion usually becomes evident in the first few years after clearing and cultivation, and is particularly evident during periods of drought and on land which is over-stocked.

The replies indicate a general confidence that control would be effected when better seasons occurred and that an improved adjustment of farm management would be effective in limiting wind erosion to a negligible extent.

3. *Soil Salinity.*—The numerous references to salt encroachment contained in the replies render it desirable to draw attention to the fact that, apart from damage resulting from the encrusted patches associated with soil salinity manifestations, there is accelerated wind and water erosion on account of the lack of vegetation. These bare, saline patches often form the heads of gullies and washes, and where a powdery surface forms, as is very frequent, this is blown away by the action of the wind and several inches of top soil have been removed in many areas affected by salt encroachment.

4. *General.*—In discussing the matter of soil erosion more generally, a number of farmers have expressed a desire for legislation to compel proper attention to the problem of soil erosion. The matter of conserving belts of timber, planting of wind breaks, conservation of timber along roads, and the surveying of wider roads where timber could be specially protected, have been mentioned.

One farmer suggested that an inspector should be appointed with power to quarantine areas liable to soil erosion.

Only a few farmers drew attention to the economics of soil erosion control measures or suggested the need for Government assistance. Some pointed out that low prices and poor seasons had limited the farmer's ability to undertake such conservation work, but there appeared to be a very general appreciation on the part of farmers, of the need for soil conservation and a great many had already adopted some control measures.

There seems to be need for technical advice to assist the farmers in using their efforts at soil erosion control to the best advantage. From the numerous offers of assistance to Government officers working on soil erosion control, it seems that farmers generally are now ready to undertake appropriate measures for soil conservation before the problem reaches a degree of even moderate severity.

Future Programme of the Soil Conservation Committee.

While it is recognised that soil erosion is widespread in the agricultural areas of Western Australia, in general damage it has not reached serious proportions but it is increasing in many cases.

As conservation is much to be preferred to reclamation, an active educational programme is to be organised to assist in the development of conservation methods, as well as demonstration of control methods. To this end it is planned to arrange conferences of Government officers at convenient centres in order to consider thoroughly the matter of soil erosion and its control under local conditions, and to lay down principles as a basis for uniformity of advice and action. These officers will undertake advisory work and practical demonstrations so that farmers may be acquainted with the most effective and efficient means of combating soil erosion on their own farms and of organising their farming practice to arrest the damage and promote reclamation.

The Thanks of the Soil Conservation Committee.

The Soil Conservation Committee expresses its appreciation of the work of farmers who have supplied information in reply to the questionnaire. It was evident that no effort was spared to give a reliable and considered report on erosion as it affected their individual farms and surrounding districts, and all are asked to accept the committee's thanks.

S. L. KESSELL,
Chairman.

L. J. H. TEAKLE,
Secretary.
Soil Conservation Committee.

Subsoiling with Explosives.

V. CAHILL.
Horticultural Instructor.

In areas where agricultural soils are underlaid with layers of stiff clay or by hard-pans, considerable benefit is often obtained by subsoiling with explosives. Under such conditions subsoiling allows of adequate drainage during the winter months and so prevents waterlogged conditions associated with shallow-rooting of plants. The deeper rooting consequent on the opening of the subsoil permits roots of plants to develop over a greater area from which plant nutrients may be obtained.

This loosening of the subsoil is particularly important where orchards have been established on soils below which compact clays or hard-pans of various types are found if for no other reason than to enable trees to obtain sufficient supplies of water, during the summer months, for growth and fruiting. The effects on trees of winter waterlogging of the roots are only too well known for orchardists not to appreciate the benefit to be derived from improved drainage on such subsoils.

In connection with the loosening of hard subsoils, Mr. A. Despeissis (1) writes: "Good results have been obtained by using explosives to crack the subsoil where it is intended to set trees or by blasting the ground in the winter in the proximity of trees already planted."

Further, Mr. H. C. Coggins (2) in a paper dealing with subsoiling in various parts of New South Wales on a number of soils, states that he finds subsoiling with explosives is by far the cheapest and best method, even for breaking up hard-pans which are created by constant ploughing at the one depth. This applies also to old jinker tracks and roads through orchards.

In many orchards it will be found that practically all of the rooting system is very close to the surface and this is very liable to be damaged by deep ploughing. The use of explosives enables subsoiling to be done without the removal of the top soil and it causes a series of fissures in the subsoil extending in all directions. The holes in which the charges are placed are spaced so that the resulting fissures from the separate charges meet, and a complete network is formed.

By using explosives, one man equipped with a few tools, namely, a two inch bull nosed auger, a tamping rod, and a pointed crowbar, can obtain an effect which could only be procured by considerable expenditure by any other method

Trials with Explosives.

In response to several requests for information regarding the use of explosives, interest was taken in this type of work carried out in the orchard of Mr. C. H. Hunter at Clackline, in 1932. The operations were spread over two acres of orchard, consisting of citrus, stone fruit and pear trees. The subsoil in this orchard is of a stiff clay nature and the work was done during the season March-April.

Single charges consisting of four-ounce plugs of "monobel" explosive were placed in holes three feet deep in line with the trees, six feet apart. It was estimated that the subsoil was disturbed to a radius of seven to nine feet by the resultant explosions. The results of this treatment have been very satisfactory as the trees have made excellent growth since that time.

In 1936, during the late summer, another trial was made at Mr. L Bassola's orchard at Chidlow, where an area consisting of four rows of four-year-old apple trees was treated similarly. These trees are now growing more vigorously than the other trees on untreated portions of the orchard.

In 1935 Mr. E. G. Bullen, of Wooroloo, carried out some similar work, using dynamite, in connection with pear trees which had previously made poor leader growth. This year the trees are making good terminal growth and are in a mucn more vigorous condition, also carrying a good crop of fruit.

Method.

The amount of explosive to be used in the holes will vary somewhat with the type of subsoil. For this reason a test hole should be put down about three feet deep and a four ounce plug of explosive fitted with safety fuse used. A slow acting explosive such as "monobel" has given the best results in the trials carried out.

Safety fuse as used for blasting purposes burns and does not explode. For detonation of the explosive it is advisable to use detonators of type No. 6.

Effect of Test.

To determine the effect of the test an excavation should be made a few feet away from where the test charge was exploded. Fractures observed will enable the operator to form a very good idea of the nature of the result. A poor fracture of the subsoil as seen in the excavation will indicate that more explosive is needed or vice versa.

When the size of the charge to be used has been determined, holes should be bored 2ft. 6in. to 3ft. deep and spaced six to ten feet apart depending on the nature and strength of the subsoil or hardpan as indicated by the test. Where the subsoil consists of a stiff, impervious clay, best results are obtained when the ground is dry as when wet such subsoils are liable to pug and will not shatter.

Summary.

1. Trials show that when hardpans, etc., have been treated by the use of explosives, fruit trees make more vigorous growth.

2. Details are given of the method used.

3. Subsoiling by explosives is warranted only on soils where an impervious layer of definite thickness exists.

The advantages of subsoiling by explosives are as follows:—

1. Conservation of moisture.
2. Better drainage.
3. Better aeration.
4. Roots of the plants are able to penetrate deeper.

The amount of "monobel" explosive used per acre in the trials cited above was one case consisting of 200 cartridges, costing £2 2s. 0d.

Literature Cited.

(1) Despeissis, A. The Handbook of Horticulture and Viticulture of Western Australia. Third Edition, p. 14, 1921.

(2) Coggins, H. C., "Subsoiling," Farmers' Bulletin, No. 69, pp. 26-32, Department of Agriculture, New South Wales.

Experiments on Copper Deficient Land at Dandaragan, Western Australia.

By L. J. H. TEAKLE,[1] A. G. TURTON,[2] and G. L. THROSSELL.[1]

INTRODUCTION.

The settlers in the Dandaragan area have long known that, under ordinary farming practice, certain classes of soil, apparently normal in general properties, are unsuitable for the growth of cereal crops and, after clearing, have a value for grazing purposes only. Some settlers have explained that the reason for these crop failures is an excessive richness in the soils which "burns" the growing crop and, in consequence of the unsatisfactory returns, development of these types of soil has not been extensive. However, in spite of the advice of settlers with a wide experience of local conditions, Mr. Brown of "Bidgerabbie," Location 1466, Dandaragan, cleared some 150 acres of blue gum flat country on his property in 1931 with a view to growing cereal crops as an adjunct to stock raising. The class of land closely resembled that associated with earlier crop failures in other parts of the district and neighbours predicted disappointing returns.

Barley was the first cereal crop on the area represented by the plots described in this paper and was scratched in on the newly cleared land in 1932. A good growth of straw was produced, but the heads failed to fill satisfactorily with grain over portions of the crop. After four years of pasture the paddock was fallowed in 1937 and sown in the middle of May, 1938, under excellent conditions, with oats, wheat and rye. Over considerable portions of the area the oats and wheat proved a complete failure and satisfactory growth was obtained only on the marginal portions of the field in proximity to the sandplain country to the east. Even here the grain was badly shrivelled.

A report of this crop failure was communicated to the Hon. Mr. P. D. Ferguson, who wrote to the Department of Agriculture on November 22nd, 1938, requesting that an examination be made to ascertain the reason for the blighting of the crops under conditions under which excellent returns could reasonably be expected.

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[1] Department of Agriculture. [2] Chemist, Government Chemical Laboratory.

A field inspection was made by the senior author on November 26th just prior to harvesting and full details obtained from Mr. Brown. In describing the growth of Burt's Early oats during the season he explained that apparently the germination was quite satisfactory and the crop grew normally for about four weeks. In the following weeks, however, it became pale in colour and drooping in habit. Closer examination showed that the tips of the leaves and the edges of the leaf blades had turned a pale yellow. With the advance of time the tips coiled to give a stringy appearance with frayed ends. The leaves and stems lacked sufficient strength for normal erect growth, and the rooting system was very poor. As the season progressed most of the plants died out and the area was covered mainly by weeds such as flat weed (*Hypochoeris glabra*), drake (*Lolium temulentum*) and a number of other species, including *Cotula australis*. Where the crop had made better growth in the more marginal areas, the yield was low and the grain small or shrivelled.

In the case of rye the growth generally was much better than with wheat or oats, but, in many instances, the top portion of the ear had failed to fill, and grain occurred only in the bottom part. In extreme cases no grain at all had formed in the rye ears.

Throughout the area a number of large bushes of wild radish (*Raphanus raphanistrum*) were observed; these had made vigorous early growth but with maturation were failing to flower normally. The buds and flowers were small and the seed pods, in most instances, had failed to grow or set seed, giving a blighted appearance. Some of the leaves showed a yellow chlorosis between the veins and only a pale green coloration on the veins themselves.

The symptoms described by Mr. Brown very closely paralleled those published by Riceman and Donald (1938) describing their experience with crops grown on copper deficient soils in the south-east of South Australia and the circumstances indicated a clear case of copper deficiency. In view of this, and in order to obtain information which would lead to a practical solution of the problem, arrangements were made for the carrying out of a comprehensive fertiliser experiment to be commenced in May, 1939. It was hoped that the results would be of value on Bidgerabbie and also to other settlers farming similar land.

The Dandaragan area lies at the northern end of the jarrah belt of Western Australia and botanical examination shows the principal vegetation associations to resemble closely those of the Perth area. The rainfall is generous and averages nearly 27 inches per annum distributed as shown in Table 1.

TABLE 1.

RAINFALL RECORDS FOR DANDARAGAN IN POINTS.

(100 points = 1 inch.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1939	208	239	3	34	402	635	812	574	37	121	69	12	3,146
Average 1898–1938...	27	43	79	118	361	534	532	411	288	182	45	41	2,661

Geologically, the Dandaragan district is typically an exposure of Cretaceous sandstones, chalks and greensands similar to those at Gingin (Hosking and Greaves (1936)). The soils are generally similar to the Gingin types but a larger proportion of the heavier textured groups occur. As at Gingin, lambs and foals depastured solely on Dandaragan country become affected by enzootic ataxia or "rickets" which Bennetts and Chapman (1937) and Bennetts (1937) have shown to be a copper deficiency disease. This disease may be controlled by the administration of copper drenches or licks, or by topdressing pastures and crops with fer-

tilisers containing copper. On account of the incidence of enzootic ataxia, Mr. Inglis, of Yathroo Station, which joins Bidgerabbie, used fertilisers containing copper in 1938 and reported improved crop growth. This evidence strongly supported the diagnosis of acute copper deficiency as the cause of the crop failure under investigation.

PHYSIOGRAPHY AND SOILS.

The area concerned in the crop failure consists of an extensive flat surrounded by sandy rises. Soils related to the Koorian sand and Whakea sand of the Gingin district predominate on the western side, and on the eastern side the land rises to the gravelly sandplain typical of the Jurassic plain which extends to the north. There is little doubt that these flats represent an old lake bed which has been dry in modern times. With the receding of the waters there developed a cover of blue gum or flood gum (*Eucalyptus rudis*) with a sprinkling of marri (*E. calophylla*) along portions of the marginal areas. Ironstone gravel occurs in the marginal areas adjacent to the Jurassic sandplain and it is on these marginal areas that most satisfactory cereal crops are obtained. The most complete failure is in the central portion of the flat. Here growth to maturity occurs only on small patches which are apparently slightly raised above the general level. Throughout this central portion fragments of opaline casuarina stone* occur on the surface and casuarina stone appears to underlie the formation at a depth of 2 to 3 feet or more.

The colour of the soil is generally grey or grey brown, but browner patches occur in portions, particularly where the elevation is slightly above the general level.

A peculiar feature of the soils is their light, powdery nature. Their apparent specific gravity is only about two-thirds of that expected of mineral soils of similar texture. The most deficient soil types appear to be those which are lighest and most powdery in structure.

The characters of representative profiles are indicated by the following details:

Site 1: A grey soil type where oats were a complete failure.

0-3 ins. brownish grey loamy silt with opaline fragments.
3-12 ins. light grey loamy silt with harder particles.
12-22 ins. light grey to olive silty loam with harder fragments.
22-30 ins. olive clay to decomposing casuarina stone.

Site 2: Marginal area where York gum (*Eucalyptus foecunda* var. *loxophleba*) and marri were intermixed with the flood gum under virgin conditions. Dundee wheat had made fair vegetative growth but the grain was shrivelled.

0-3 ins. grey brown loamy sand.
3-9 ins. brown loamy sand.
9-21 ins. light fawnish brown light sandy loam with some fragments of casuarina stone at 24 inches.

Site 3: Complete failure of wheat and heads of rye almost invariably empty, regrowth occurring from the bottoms of the plants.

0-3 ins. grey brown silty loamy sand with opaline fragments.
3-15 ins. light brown loamy silt.
15-36 ins. khaki brown heavy sandy loam with odd opaline fragments. Cementy, sandy layer at 36 inches.

*Casuarina stone is a more or less consolidated diatomaceous earth.

Site 4: Oats a complete failure.

0-3 ins. brownish grey silty loamy sand.
3-7 ins. somewhat more compacted.
7-15 ins. pale bluish grey gritty silty sandy loam with opaline fragments.
15-24 ins. olive sandy clay loam with casuarina stone at 27 inches.

These soil samples have been examined for apparent specific gravity, salt, reaction, replaceable bases, phosphate, potash and copper. The results are given in Table 2.

TABLE 2.

PROPERTIES OF SOIL SAMPLES FROM THE AREA ON MR. J. A. V. BROWN'S PROPERTY, BIDGERABBIE WHERE CROP FAILURES HAVE BEEN OVERCOME BY MEANS OF THE USE OF BLUESTONE AS A FERTILISER.

Site.	Serial No.	Depth.	Nitrogen	P_2O_5.	pH.	Salt.	Apparent* gravity.	Replaceable cations. m. eq. per 100 gm. soil.	Per cent. of total cations other than hydrogen. Ca.	Mg.	K.	Na.
		inches	%	%		%						
1	2628	0—3	·200	069	5 31	·06	1 05	11 75	38	45	7	10
	2629	3-12	·055	·032	5 31	·02	1·09	7·29	20	65	5	10
	2630	12-22			6·20	·02	1·24					
	2631	22-30			7 18	02	1·03					
	2632	0- 3	·102	·045	6 09	·01	1·46	6·78	75	19	6	Tr.
	2633	3- 9	063	·044	6·07	·01	1 50	5·00	76	17	7	*nil*
	2634	9-21			5·01	·01	1·35					
3	2635	0- 3	140	·099	5·60	·02	1·06	8·21	67	23	10	Tr
	2636	3-15	·076	093	5·45	·01	1 12	6 89	55	33	11	1
	2637	15-36			4·94	·04	1·24					
4	2638	0- 3	·284	160	5 37	·07	·90	12·28	48	37	10	5
	2639	3- 7	·161	136	5·45	·03	·98	9·59	31	54	6	9
	2640	7-15			5 96	·04	1·11					
	2641	15-24			7·41	·05	·99					

* Apparent specific gravity determined by weighing a standard volume of air dry soil after sieving through a number 10 sieve. The result is expressed as a multiple of the weight of the same volume of water. Apparent specific gravity normally ranges from 1·2 for clays to 1·7 for sands. Ordinary soils of this texture would be expected to have an apparent specific gravity of about 1 5.

Copper contents as determined by the dithizone method was of the order of magnitude of 1-2 p.p.m on the dry soil basis.

The copper estimations showed that the copper content was of the order of magnitude of 1 to 2 parts per million in the surface soil of each site. Thus, the site representing country on which wheat was not a complete failure appeared to have practically the same copper content as where cereals failed completely. Chemical examination failed to detect a significant difference.

The chemical analyses show the soils to be quite normal for this rainfall belt, that is, they are typical of the zone of podsolised or leached soils, Teakle (1938). The reaction is acidic and the replaceable cations other than hydrogen are principally calcium and magnesium. The phosphate status is considerably better than for most Western Australian soils and, in this respect resembles some of the better soil types at Gingin. Potash may be regarded as moderate.

FERTILISER EXPERIMENTS.

In order to ascertain the response of crops grown on this class of country to minor elements, particularly copper, an experiment was designed with the following objects:—

(a) To determine whether the addition of copper to the ordinary fertiliser would affect the growth of oats.

(b) If so, to indicate how much copper must be applied in the form of bluestone.

(c) To ascertain whether growth of cereal crops would be further improved by the inclusion of other minor elements.

A 5 x 5 randomised block layout was adopted to obtain accurate yield data to answer these questions and the following treatments were used*:—

A. Control, 1 cwt. of superphosphate per acre.

B. 1 cwt. of superphosphate mixed with 5 lbs. of bluestone per acre.

C. 1 cwt. of superphosphate mixed with 15 lbs. of bluestone per acre.

D. 1 cwt. of superphosphate mixed with 30 lbs. of bluestone per acre.

E. 1 cwt. of superphosphate mixed with 15 lbs. of bluestone, 15 lbs. manganese sulphate, 20 lbs. magnesium sulphate, 20 lbs. ferrous sulphate, 5 lbs. zinc sulphate, 5 lbs. borax per acre.

The experiment was conducted on a portion of the flat on which the cereal crop had failed completely in 1938. The stubble was burnt where small patches had made some early growth and the land disc cultivated in January, 1939. After being spring-tyned in early May to kill weeds and prepare a seed bed, Burt's Early oats at the rate of 50 lbs. per acre and the appropriate fertilisers were sown on May 13th, 1939.

THE GROWTH OF THE OATS.

Observations made during the growing season showed that germination was generally good over all of the plots. Little difference was observed between any of the treatments during the first four weeks but by the middle of June, on the control plots, the plants were beginning to show a distinct yellowness and were obviously unthrifty. Growth on the control plots had practically ceased by the beginning of August and the plants were becoming progressively more yellow, showing typical copper deficiency symptoms. Some plants were already beginning to die.

Figure 1 shows a comparison of the growth with and without copper on July 26th, 1939.

Early in September, on the control plots, most of the oats had died and only scattered survivors occurred over the plots. These showed typical symptoms of copper deficiency as described by Riceman and Donald (1938) and, in general, made practically no headway subsequently.

Figure 2 shows a general view of a control plot between two plots which had received bluestone in the fertiliser mixture. These plots are gratifyingly uniform in their growth and show a remarkably consistent response to the copper treatment. Figures 3 and 4 are close-ups of typical oat plants from the plots and show in some detail the characteristic copper deficiency symptoms on plants from the control plots.

By contrast, the other plots, which all received copper in the form of bluestone, continued to progress throughout the growing season and little difference, as a result of the various treatments which included copper in the mixture, could be observed at any period. During the first part of September the oat plants on the plots receiving only 5 lbs. of bluestone per acre certainly showed more evidence of withering of the tips of the leaves, but recovery was practically complete by the end of

*The fertilisers for these experiments were kindly supplied by Cuming Smith and Mt. Lyell Farmers' Fertilisers, Lt .

September when all copper treated plots were heading out nicely. At harvest time (November 6th and 7th, 1939), all of the copper treated plots carried an excellent growth of oats. It is true that over the length of these plots the growth showed

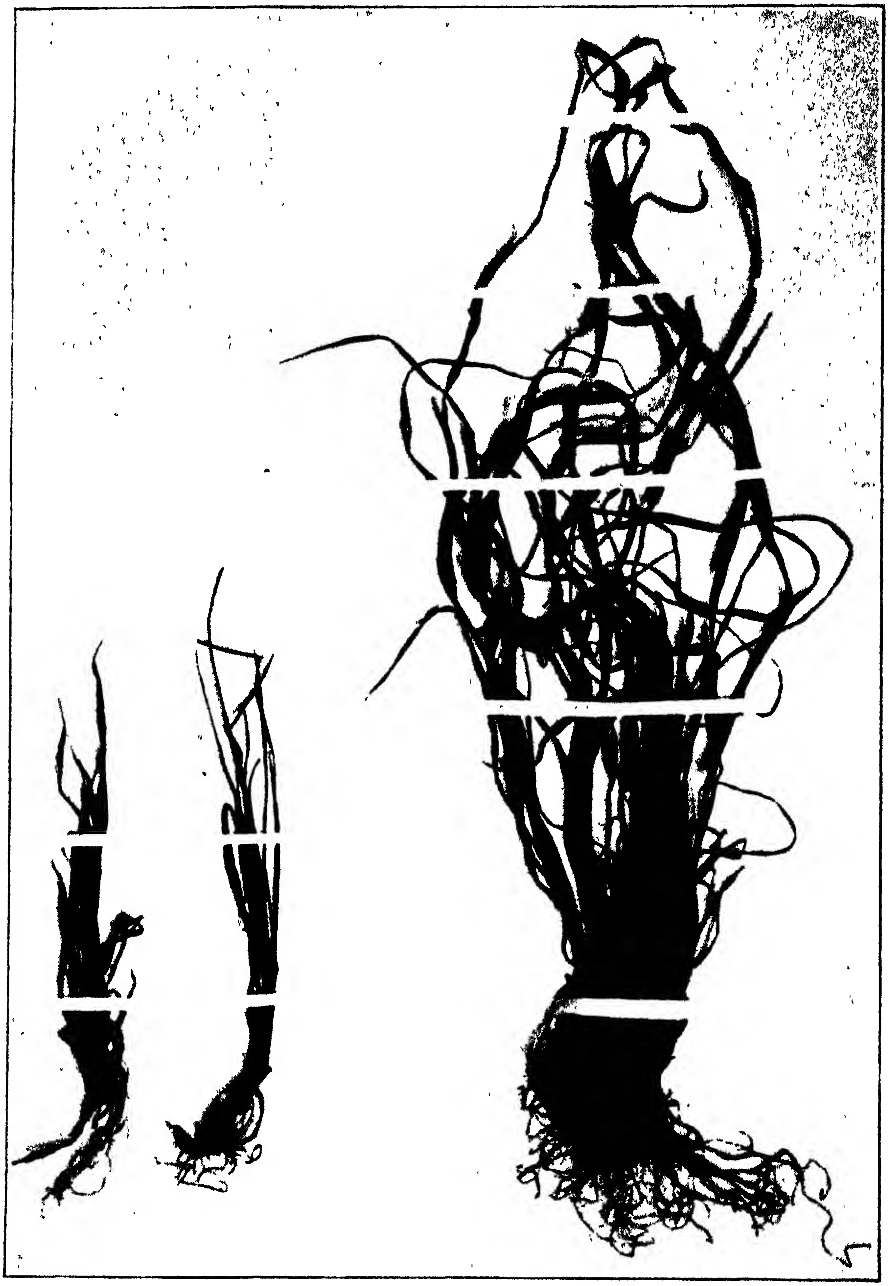

Figure 1.

Shows nature of growth of oats on plots receiving superphosphate only (left) and superphosphate plus 5 lbs. bluestone per acre. Harvested July 26th, 1939.

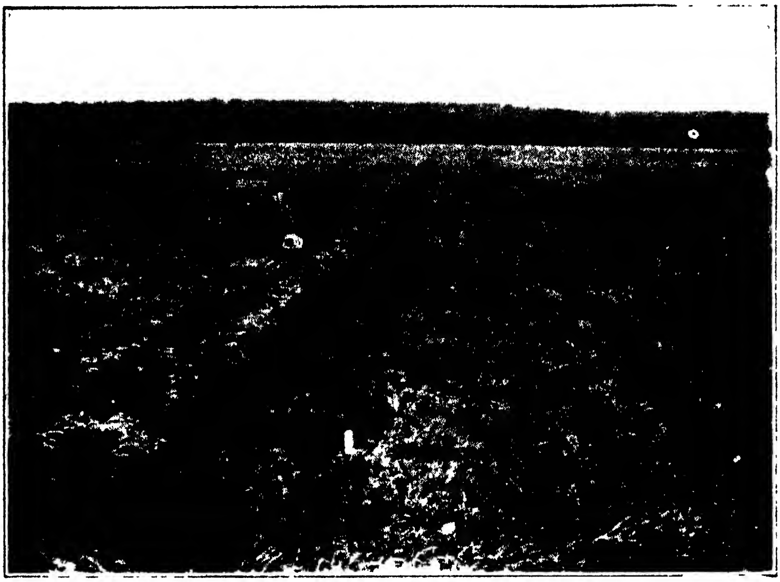

Figure 2.

General view of plots taken September 5th, 1939, showing the control plot (19) in contrast with plots receiving bluestone at the rate of 15 lbs per acre in combination with manganese, zinc, boron, iron and magnesium (left) and bluestone at the rate of 5 lbs. per acre (right). The growth apparent on the control plot (19) is principally drake (*Lolium temulentum*).

some lack of uniformity, probably due in part to the fact that the land had not been fallowed and some growth of oats had occurred in patches during the previous season, but no sign of crop failure was observed where copper had been applied.

Figure 5 gives a close-up of typical oat plants from copper-treated plots at harvest time (November 7th, 1939), in contrast with selected surviving plants, which were scattered over the control plots and had reached various stages of maturity. These show typical copper deficiency symptoms.

As a satisfactory machine was not available to harvest the plots, estimates of yields were obtained by means of 36in. x 35in. quadrats taken at eight sites selected at random in each plot. By this means no loss of material was incurred and the yields reported represent the total material produced.

The yields exceeded all expectations and comparison of the returns from the various plots showed that there was no significant difference due to any of the variations in the copper treatment. The controls (receiving no copper) were practically a complete failure and no yield estimates were obtainable from any part of the five replications.

The hay and grain yields estimated from the quadrats are given in Table 3.

TABLE 3.

HAY AND GRAIN YIELDS FROM THE VARIOUS TREATMENTS ON THE DANDARAGAN PLOTS. ESTIMATED FROM THE WEIGHTS OBTAINED FROM QUADRATS 36IN. x 35IN.

——	Hay Yield per acre.		Grain Yield per acre.
	tons.	cwts.	bus.
Superphosphate only	*Nil*		*Nil*
Superphosphate plus 5 lbs. of bluestone per acre ...	3	14	45·5
Superphosphate plus 15 lbs. of bluestone per acre ...	3	14	45·6
Superphosphate plus 30 lbs. of bluestone per acre ...	3	14	50·7
Superphosphate plus complex mixture ...	3	16	49·2

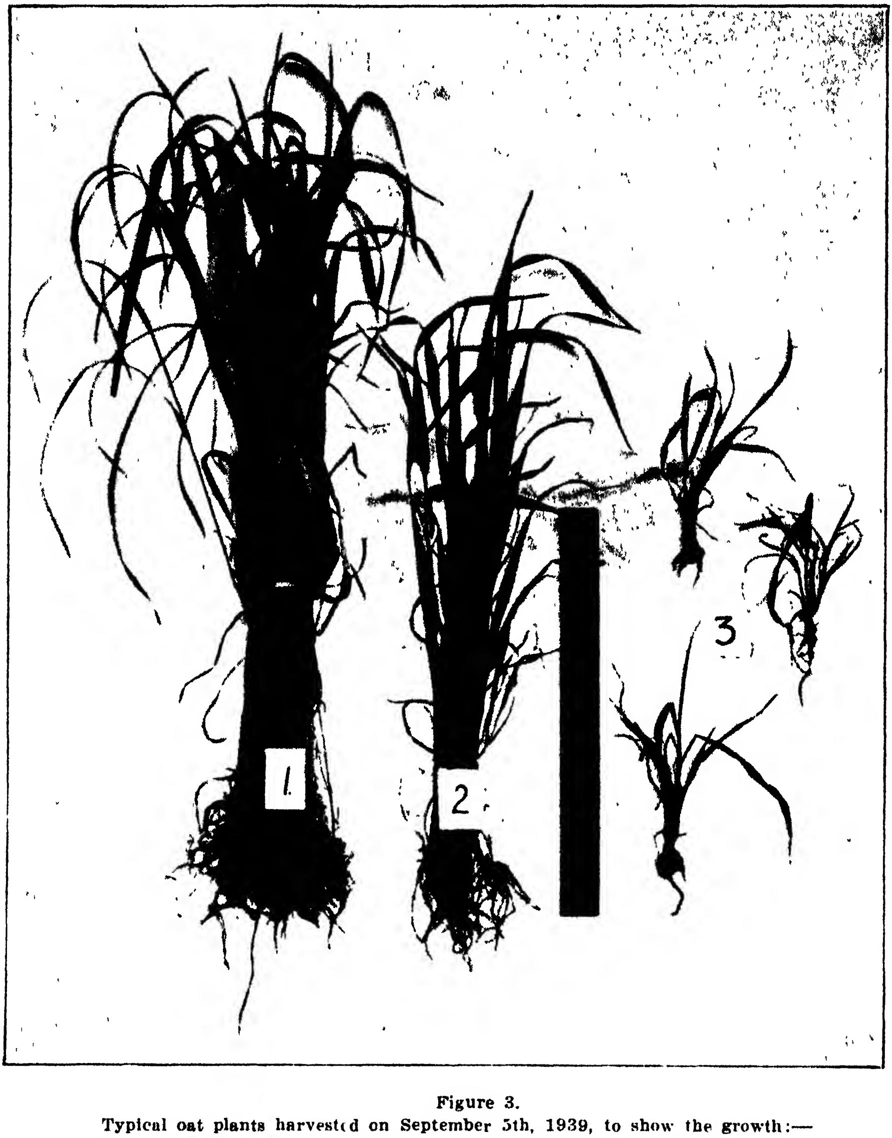

Figure 3.
Typical oat plants harvested on September 5th, 1939, to show the growth:—
(a) with bluestone (Specimens 1 and 2) and
(b) without bluestone (Specimen group 3).
(The scale is 15 inches long.)

The grain from all plots was rather thin but gave a bushel weight of 38.5 lbs. determined by the chondrometer.

Statistical examination of the harvest returns shows that the differences between the hay and grain yields on copper treated plots are too small to be significant and are most probably the result of chance variations in the fertility levels of the soil on different parts of the experimental area. It is of very considerable interest that no improvement in yield resulted from the use of bluestone in excess of 5 lbs. per acre or when mixed with other elements.

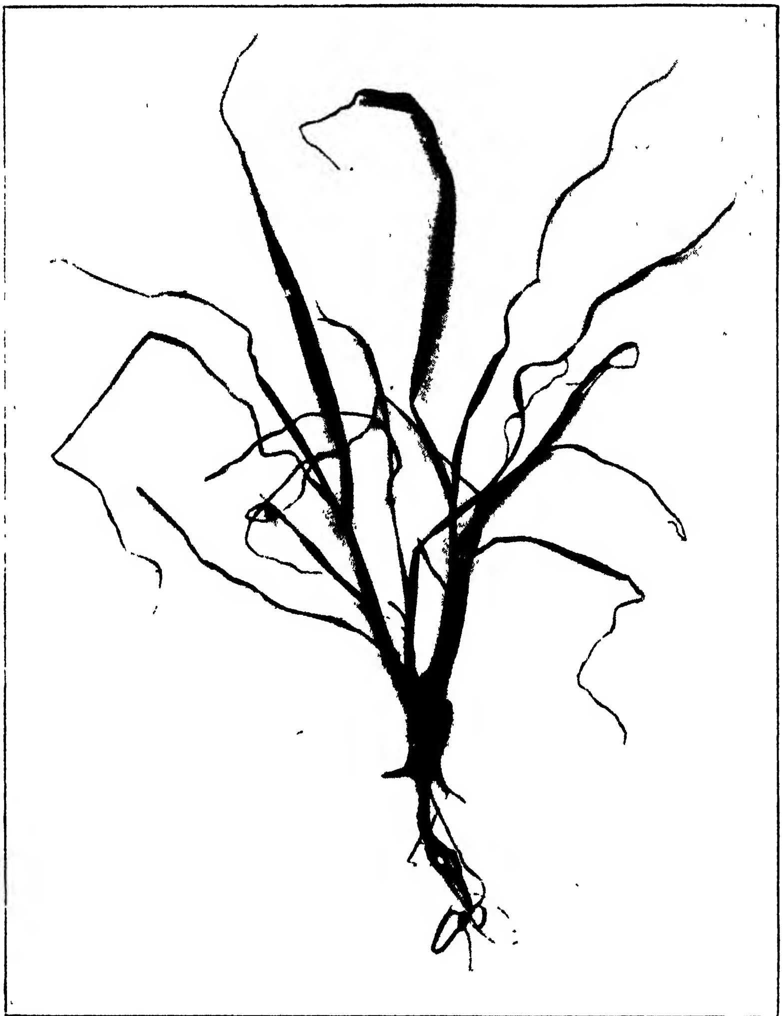

Figure 4.

Oat plant harvested on September 5th, 1939, from the control plot to show the typical copper deficiency symptoms exhibited on the Dandaragan plots. Note the stringy tipping of the leaves and the tendency for the leaves to die back from the tips and along the edges. Rooting system is very poor.

The weeds were fairly prevalent throughout the plots and had practically taken possession on the controls where the oats had died. Drake was the principal weed and had made vigorous growth throughout. Other weeds included chick weed (*Stellaria media*) and a small annual known as *Cotula australis*. Yathroo oat occurred as a weed throughout the plots. Apparently these weeds are all more or less tolerant of copper deficiency conditions.

EXAMINATION OF THE OATS.

In order to obtain information concerning the chemical composition of the oats and any anatomical differences which may be associated with the various treatments, samples were taken on September 5th, 1939, for chemical analysis and microscopical examination. At this time, the surviving oats from the control plots

were 6 to 8 inches high and had only produced four or five leaves. They had not yet begun to run up preparatory to ear formation (Figures 3 and 4). On the other hand, on the copper treated plots the oats were 24 to 30 inches high, had produced five or six leaves and were beginning to run up into ear. (Figure 3.)

Figure 5.

Mature oat plants at harvest (about 4½ to 5 feet tall) from plots receiving copper (left), in contrast with selected surviving plants from control plots (right) which show typical copper deficiency symptoms.

It is evident that, in the absence of copper, development had been arrested and these plants were physiologically and anatomically younger than those which had received copper. For that reason alone it would be expected that chemical and anatomical differences would be observed on examination. Differences may also be due to deficiency of copper giving rise to abnormalities. Examination of the plant material from each of the 25 plots for chemical properties in the Government Chemical Laboratory gave the results summarised in Table 4.

TABLE 4.

COMPOSITION OF OAT PLANTS FROM THE BIDGERABBIE PLOTS HARVESTED ON 5TH SEPTEMBER, 1939.

(Results expressed on the basis of oven-dry material.)

Treatment.	Total Ash.	Silica-free Ash.	Total Nitrogen.	Copper (Cu).
	%	%	%	p.p.m.
Control—Superphosphate	13·03	8·50	2·83	1·9
Superphosphate plus bluestone, 5 lbs. per acre	9·06	5·76	1·29	3·4
Superphosphate plus bluestone, 15 lbs. per acre	10·59	6·62	1·59	3·7
Superphosphate plus bluestone, 30 lbs. per acre	9·07	5·64	1·25	2·9
Superphosphate plus mixture containing copper, manganese, zinc, boron, iron, and magnesium	8·66	5·20	1·08	1 9

Statistical examination of the results show that—

(a) the total ash content was higher in the controls;

(b) no significant differences occurred in the copper contents of the plant material under the several treatments;

(c) the percentage of nitrogen was greater in the controls than in any other treatment but there were no significant differences in nitrogen content of the plant material from the various copper treatments.

Work reported by Piper (in press) in Adelaide supports the evidence obtained in these experiments concerning the effect of copper treatment on the copper content of oats. It seems unfortunate that oats show such a small copper content and do not exhibit a more consistent response in copper content when treated with copper containing fertilisers even on highly copper deficient soils. Of course, the total absorption of copper from the soil under the copper treatments would be very greatly in excess of that from the controls on account of the increased amount of growth which has been made. Yield figures which would enable the difference in total amount of copper absorbed to be estimated were not obtained. Furthermore, although statistical analysis indicates the apparent differences in copper content of the oats under the various treatments may not be significant, it seems that a grazing animal would have a better chance of obtaining more adequate copper requirements from crops receiving the copper fertiliser.

Observations by Miss Ford of the University Department of Botany reported in the Appendix, show marked microscopic differences between the control plants and those receiving copper when sampled on September 5th, 1939. Of course, some of these differences may be due to the arrested stage of development in the case of the plants from the control plots, but it is most likely that certain of these features are characteristic abnormalities exhibited under copper deficient conditions. It is hoped, however, that extension of such anatomical studies may lead to further information of value in connection with an understanding of the facts and functions of minor elements.

GENERAL OBSERVATIONS.

The early results of this work led Mr. Brown to use bluestone as a fertiliser fairly generally during 1939 on portions of his farm, and particularly in the home garden. The home garden is on a type of soil rather closely resembling the orange coloured Koorian sand of Gingin. Bluestone treatment has effected marked recovery of fig trees affected with mottle leaf. Maize is producing long, well filled cobs which are in marked contrast to those of previous years when only odd grains set. Tomatoes are bearing very much better than previously, apparently due to the use of bluestone.

However, strip experiments to observe the effect of bluestone on the growth of wheat on Koorian sand near the homestead failed to give any consistent results. Apparently, the Koorian sand is far less deficient in available copper supplies than the blue gum flat soils, but it seems likely from the responses of the maize, tomatoes and figs, that, with further cropping, copper deficiency with respect to cereals may manifest itself.

FUTURE EXPERIMENTS.

These plots are to be carried on for a number of years; in 1940 they will be sown to subterranean clover and wimmera rye grass; in 1941 they will again be sown to oats and half of each plot will receive the appropriate minor element treatment while the other half will receive superphosphate only to ascertain the residual value of the copper treatment. This rotation will be repeated for at least another two years.

In addition a further experiment is being laid down adjacent to the one just described, in order to ascertain the effect of smaller amounts of bluestone, namely 1, 2½ and 5 lbs. per acre. Further, the value of copper from oxidised copper ore obtained from Ravensthorpe will be determined as this source of copper is available at about one quarter the cost of the refined bluestone. Pyrites slag from Messrs. Cuming Smith & Mt. Lyell Farmers Fertilisers Ltd. residues, which contains between 1 and 2 per cent. copper, will also be tried.

Similar experiments have already been arranged on Mr. C. J. Roberts' property, "Kayanaba" and V. G. Rennie's property, Gingin.

A simple observational experiment will be conducted on "Yowerdabbie," Dandaragan, on soils of the Whakea sand and Koorian sand types.

CONCLUSIONS.

From these results it may be concluded that the crop failure under investigation was due to copper deficiency and excellent crops may be produced on the soils in question if copper is applied as a fertiliser. Five pounds of bluestone per acre mixed with superphosphate gave yields equal to any other treatment and no advantage was gained under these conditions from heavier applications. Less may suffice.

Analysis of the soils is not a satisfactory guide to copper deficiency. Observation of the symptoms exhibited by an indicator crop such as oats, or maize, followed by field trials, is the surest method of detecting such soil deficiencies.

It is not to be expected that such remarkable responses to the use of bluestone will be obtained generally on soils which are characterised by unsatisfactory crop growth. In fact, many experiments prove that such is not the case. However, there are patches of country, in the aggregate amounting to many thousands of acres and favourably located in the present agricultural areas, on which unsatisfactory returns are being obtained both from stock and crops as a result of copper deficiency. When these areas have been determined by means of field experimentation the efficiency of agriculture on these particular areas will be considerably

improved by the use of fertilisers containing copper. Farmers are advised to experiment before undertaking extensive fertiliser dressings with bluestone and similar amendments, as not only are these costly, but on some soils they have been known to bring about depressions in yields, even when used in such small quantities as 15 lbs. per acre. District agricultural advisers will give advice on the use of these special fertilisers and will assist farmers in planning simple experiments on their farms to determine the value of minor elements as adjuncts to the ordinary fertilisers.

ACKNOWLEDGMENTS.

Appreciation and thanks are tendered to Cuming Smith & Mt. Lyell Farmers' Fertilisers, Ltd., for the donation of the mixed fertilisers used in these experiments.

Grateful acknowledgment is made to officers of the Forests Department for the statistical examination of the results from the field and laboratory work, and to Mr. B. L. Southern, of the Government Chemical Laboratory, for assistance in the chemical work.

Special thanks are due to Mr. Brown who undertook the cultural operations involved and erected the necessary fencing.

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Appendix.

Anatomical Investigations of Oats (Burt's Early) obtained from Experimental Plots on Copper Deficient Land at Dandaragan.

by

J. M. FORD.*

The investigation was undertaken to discover if oats, grown on the control plots and showing typical copper deficiency symptoms on Mr. J. A. V. Brown's property, "Bidgerabbie," differed anatomically from those grown on the plots receiving copper treatment in addition to the usual superphosphate.

At the time of collection, September 5th, 1939—12 weeks after planting—the plants were very different in external appearance in comparison with the healthy plants receiving copper; those suffering a deficiency of copper were stunted in growth and possessed a poorly developed root system. A noticeable feature was the restricted elongation of the internodes which resulted in the nodes (or knots of the stem) being close together at the base of the plant. Other symptoms have been mentioned and are illustrated in figures 3 and 4.

*Hackett Scholar in Botany, 1939, University of Western Australia.

Results of Anatomical Investigation.

In order to determine the structural differences between the leaves and stems of affected and copper treated plants, sections of representative material were cut and examined by means of the microscope. Figure A shows transverse sections of the

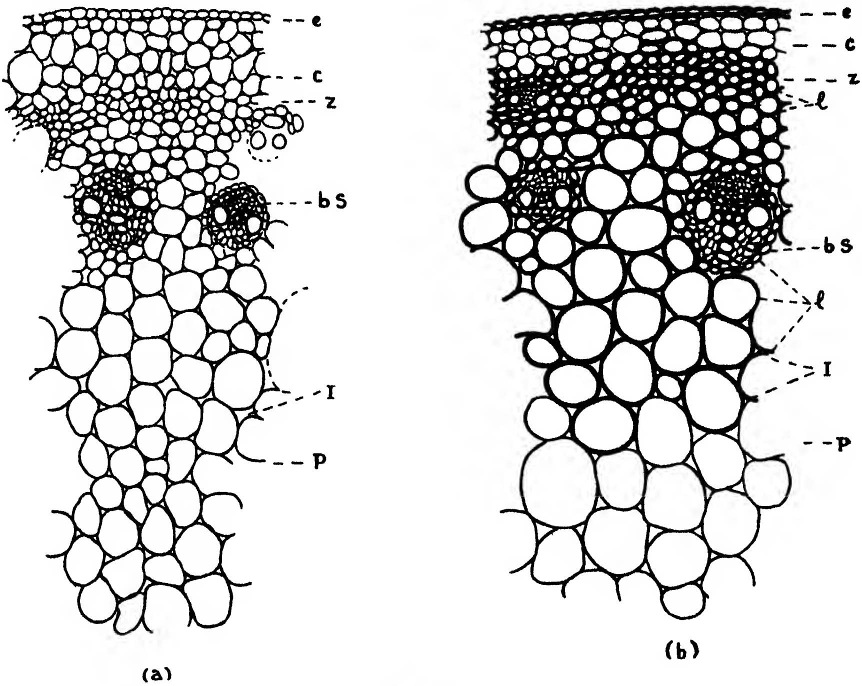


Figure A

Transverse section of the stem of oat plants harvested on September 5th, 1939 :—.

(a) Control plant suffering from a deficiency of copper.

(b) Plant from adjacent plot receiving 30 pounds of bluestone per acre.

e = epidermis, C = cortex, Z = zone of lignified cells in cortex, b.s. = thick walled cells of the bundle sheath, I = marked intercellular connections of the outer pith cells, P = pith cells.

Magnification x 79 (camera lucida).

stem (a) of a control plant suffering from a deficiency of copper and (b) of a plant growing on soil receiving 30 lbs. of bluestone per acre, in addition to the usual phosphatic dressing. The section shows that the stem of the treated plant has a thickened epidermis (e), a zone of lignified cells in the cortex (c), thick walled cells of the bundle sheath (b.s.) and thickened walls with well marked intercellular connections (I) of the outer pith cells (P). In contrast to this, the stem of the deficient plants has a thin walled epidermis and in the cortex there is a similar zone of cells (Z), but these are thin walled and unlignified; the cells of the bundle sheath and pith are also thin walled. In the root there is also a lack of lignification of the walls in the deficient plants.

With respect to the leaves, figure B shows the chief difference in anatomy between the control and treated plants. The leaves of the copper treated plants have well differentiated motor cells (m.c.), numerous and usually lobed mesophyll cells (me), fairly abundant sclerenchyma (Sc) and thick cuticle (cu). The deficient plants show very little differentiation of the motor cells, smaller and more compact mesophyll cells forming a rather palisade-like mesophyll and usually fewer fibres: the cuticle is poorly developed.

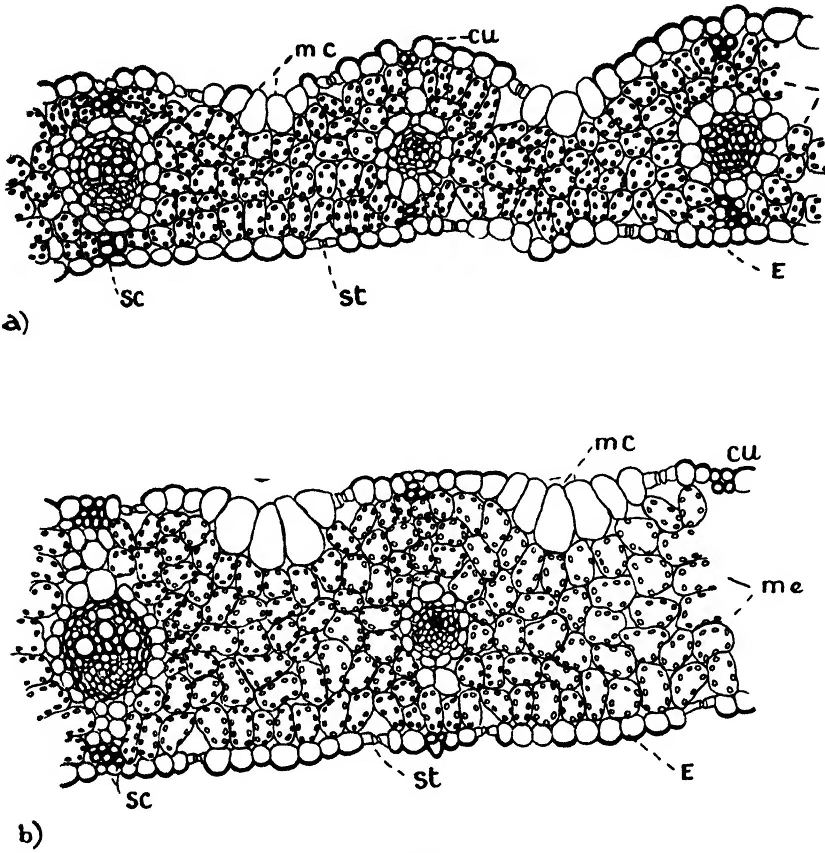


Figure B.

Transverse section of leaf of oat plants:—

(a) from control plot and suffering from copper deficiency.

(b) from adjacent plot receiving 30 pounds of bluestone per acre.

cu = cuticle, E = epidermis, m c. = motor cells, Sc. = sclerenchyma, St. = stomate, me = mesophyll cells

Magnification x 104 (camera lucida).

Where yellowing of the leaf and withering of the leaf tip occurs there are marked changes in the cell contents. The chloroplasts disintegrate and the cell contents change from green to yellow, and finally to brown tannin-like globules.

This investigation does not render it possible to say much about the chloroplasts at this stage. There was no definite evidence that malformation of the mesophyll cells or disintegration of the chloroplasts was greater in the control p'ants than the treated plants, except where withering of the leaf tips had already occurred.

The development of the hairs along the leaf edges showed marked differences which correlate with the soft feel of the copper deficient plants in comparison with those receiving adequate supplies. Figure C shows the leaf edges and illustrates the relative development of hairs in the two types. It will be noticed that in the copper treated plants the hairs are numerous and regularly spaced, but the deficient plants have fewer and smaller hairs which are irregularly spaced. This difference in hair formation was noted in other parts of the plant. A poorer development of root hairs and hooks on the ligules of the controls correlates with the relationship observed with respect to the leaf hairs.

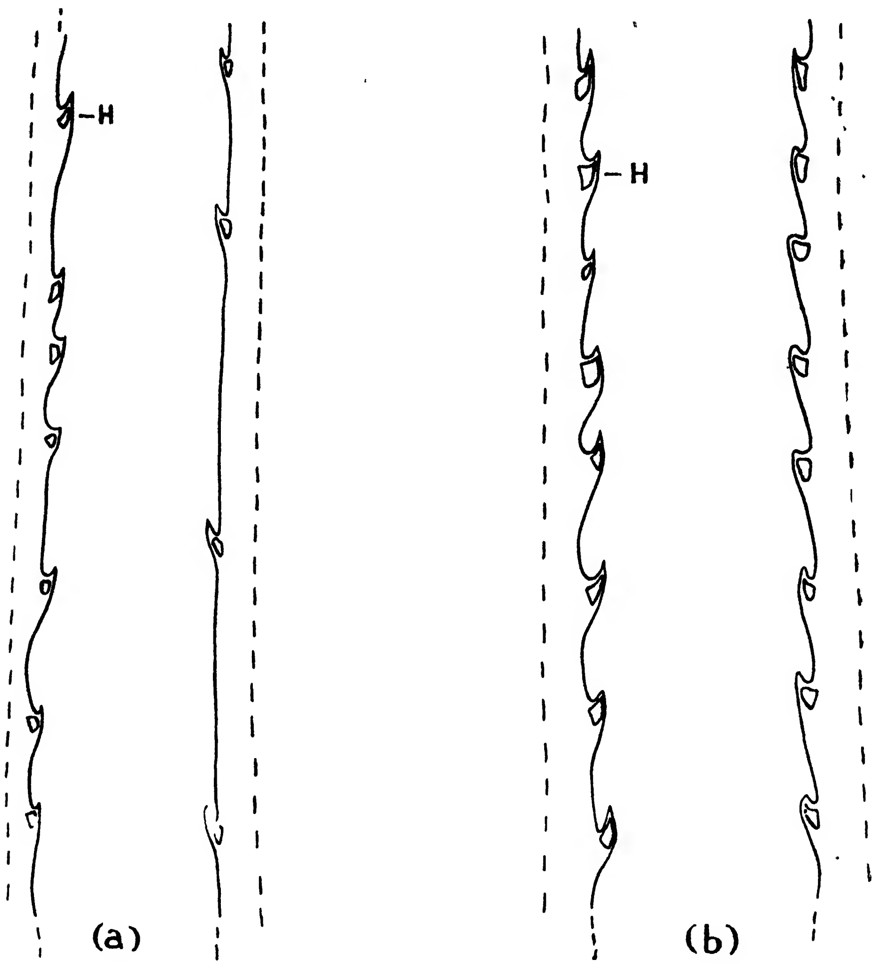


Figure C.
Silhouettes of the hairs on both edges of the leaf :—
(a) from a control plant;
(b) from a plant receiving copper at the rate of 30 pounds of bluestone per acre.

Magnification x 132 (camera lucida).

Discussion.

The above results represent only a preliminary investigation, but several anatomical differences are apparent, the most striking being the relative degree of lignification of the copper deficient and copper treated plants. The lack of thickening of the cell walls of the plants growing on copper deficient soils probably accounts for their limpness. Furthermore, the leaves show characteristic differences in hairiness and development of mesophyll and motor cells. Other minor differences were noted but further work is required to establish these, as well as the above anatomical differences, with respect to copper deficiency symptoms. It may be remarked that differences in leaf anatomy between the copper treated plants and the control plants also resembles differences obtained by growing plants in sunlight and shade. Furthermore, certain of these differences may be the result of arrested development—that is the failure of the plants lacking copper to continue their normal growth towards maturation.

Investigations of the anatomy of oat and other crops from other copper deficient areas of the State indicate similar results to those obtained with the oats at Dandaragan described above. Also, sections of plants from plots receiving 5 to 15 lbs. of bluestone per acre in the Dandaragan experiment were similar to those from plants from the plots receiving 30 lbs. per acre.

Irrigated Pasture Competition.

FINAL RESULTS.

H. G. ELLIOTT, Agrostologist.
A. R. CLIFTON, Officer-in-Charge, Irrigation.

This competition was inaugurated by the Harvey Agricultural Society in 1937. A resume of the results of the first and second years' inspection is given in the March 1938 and 1939 issues of this Journal. The object of the competition was to stimulate interest and to demonstrate methods proved successful in the management of irrigated pasture, particularly the necessity for adequate drainage.

This competition embraces the whole of the irrigation area extending from Waroona to Dardanup. The Agricultural Societies of Waroona, Harvey and Brunswick, together with the Waterloo P.P.A., also ran individual annual competitions, embracing the entries from their respective districts. In these competitions it was arranged that the pastures were to be judged twice yearly for a period of three years, and the competitor gaining the highest total number of points for all inspections was to be judged the winner.

Messrs. Cuming Smith Mount Lyell Farmers Fertilisers Ltd., generously donated a trophy valued at 10 guineas to the winner, to be presented at the conclusion of the competition. The individual Societies also awarded annual prizes for the winners in their areas.

The results of the 1939 inspections which were carried out during the months of June and December have been combined, and the results given in the following table:—

TABLE 1.

Competitor.	Mixture (20)	Sward and Uniformity (20)	Condition. (20)	Management. (20)	Layout for Irrigation and Condition of Channels. (20)	Total Points. (100)
J. Salerian, Waroona (No. 2)	18	18	17	15½	15½	84
C. E. Edwards, Waterloo (No. 1)	17½	17	17½	13½	18½	84
J. Salerian, Waroona (No. 1)	16	17½	16	15	15	79½
C. E. Edwards, Waterloo (No. 2)	15	16	15½	11	15½	73
L. Temple, Harvey (No. 1)	16	16½	13½	14	13	73
L. Temple, Harvey (No. 2)	16	16½	13½	14	13	73
E. Holthouse, Harvey (No 1)	16½	16½	15½	12	11½	72
E. Holthouse, Harvey (No. 2)	17	16½	15	11½	11½	71½
D Moore, Roelands	15	16	14½	12	14	71½
C. F. Giblett, Harvey . .	17	16	13½	9½	14	70
F. Reeves, Brunswick . .	15	14½	12½	10	11½	63½
S. Bowers, Brunswick .	14½	14	11½	10	12½	62½
W. C. Edwards, Burekup	12½	12	11	10½	16	62
H. Piggott, Brunswick .	15½	14	11½	7½	11½	60
L. C. Hynes, Waterloo (No. 2)	14	14½	11½	7	12	59
L. C. Hynes, Waterloo (No. 1)	13½	14½	11½	7	12	58½
T. P. Harris, Waterloo . . .	12½	12	9½	10	14½	58½
T. Tyrell, Waterloo . .	11½	11	9½	7½	11	50½

It will be seen from the above table that the winners of the annual prize awarded by the Agricultural Societies conducting the competition are as follows:—

Waroona Agricultural Society—Mr. J. Salerian, No. 2.
Harvey Agricultural Society—Mr. L. Temple, No. 1.
Brunswick Agricultural Society—Mr. D. Moore.
Waterloo P.P.A.—Mr. C. E. Edwards, No. 1.

It was evident from the inception that the number of entries received indicated that the settlers in these districts were keenly interested in the development of irrigated pastures. It can be said that generally, the pastures exhibited were good, some of them being capable of carrying approximately 1 cow to ¾ acre, where adequate conservation had been carried out. Results such as this have been achieved only by careful attention to watering, manuring and reasonable management of grazing in rotational methods. During the second year of the competition additional entries were received in the Waroona and Waterloo areas for the annual section of the competition.

From Table 1 it will be seen that Mr. J. Salerian of Waroona and Mr. C. E. Edwards of Waterloo, gained the same number of points to tie for first position for the two inspections during the final year. The pastures exhibited by both these men were of a high standard on the basis of a system of White Clover with Perennial Ryegrass and in the case of Mr. J. Salerian, the addition of Cocksfoot. Subterranean Clover, Lotus major and odd plants of Yorkshire Fog were evident as minor constituents in the pasture. In one or two isolated parts, couch grass had shown up, this being present in most of the irrigated pastures judged.

Table 2 gives the results of the six inspections, 1937, 1938 and 1939:—

TABLE 2.

Competitor.	1st Inspection.	2nd Inspection.	3rd Inspection.	4th Inspection.	5th Inspection.	6th Inspection.	Total
J. Salerian (No 2)	70	71	87	87	89	79	483
C. E. Edwards (No. 1)	78	82	70	74	83	85	481
J. Salerian (No. 1)	69	60	72	79	82	77	439
D. Moore	64	73½	78	76	78	65	434½
E. Holthouse (No 2)	69½	75	72	73	75	68	432½
L. Temple (No. 1)	73½	62	76	67	74	72	424½
L. Temple (No 2)	73	61	76	68	74	72	424
C. E. Edwards (No. 2)	64	76	71	63	79	67	420
E. Holthouse (No. 1)	71	50	68	75	72	72	408
S. Bowers	60	59	68	68	65	60	380
C. F. Giblett	57	47½	64	65	70	70	373½
F. Reeves	63	61	58	59	67	60	368
T. P. Harris	55	77½	54	60	57	59½	363
W. C. Edwards	47	52½	58	66	67	57	347½
H. Piggott	49½	56½	53	67	58	62	346
L. & C. Hynes (No. 2)	49½	50½	50	59	56	62	327
L. & C. Hynes (No 1)	53	45	50	59	55	62	324
T. Tyrrell	55	51½	59	48	53	48	314½

This table shows that Mr. J. Salerian's No. 2 entry gained the highest total points for the six inspections, and consequently he is the winner of the trophy donated by Messrs. Cuming Smith Mount Lyell Farmers Fertilisers, Ltd. Mr. Salerian is to be congratulated on his excellent management of this pasture. The field has been approximately rotationally grazed throughout, at intervals between grazings varying from 14 to 24 days, according to the season and growth recovery of the pasture species. This method of grazing which has, and is being practised by this farmer, leaves little to be desired, except that it may be considered his time between grazings during the flush period could be lengthened to 15-20 days, and it is also thought that during the slow growing periods, i.e., the winter

months, up to 28 or 30 days may be more beneficial than the present 24-day interval between grazings as adopted by Mr. Salerian. At present we are unable to give definite information as to the best length of time between grazings. We have indications from experiments being conducted, that during the flush periods of growth 15-20 days are more beneficial than longer periods between grazings. Full information on this subject will not be available until the conclusion of the experiments which are being carried out by this Department at present.

Renovation is carried out annually, and pasture harrows are used fairly constantly during the winter months. Topping with a mower is also carried out when required. The following factors have been obtained from the inspections which have been carried out twice yearly for a period of three years:—

1. The most important feature noticed was the fact that in every case good strains of pasture grass and clover seeds were used.

2. In many instances mistakes were made in laying down pastures too soon before the land was sufficiently well prepared. For an important crop like permanent pasture, which with proper management will be reproductive for many years, it is obvious that thorough and very careful preparation is essential to obtain the best results. It is recognised, however, that farmers generally in our irrigation areas in Western Australia have had very little time to fit their land properly for irrigation, and it is particularly interesting to note the improvement of individual farmers by comparing the layout of their initial irrigated pastures with the ones sown at a much later date.

Block showing irrigated pasture on the property of J. Salerian, Waroona, consisting of Perennial Rye Grass, Cocksfoot and White Clover.

3. It was generally found that the management of irrigated pastures had been more or less neglected, more particularly with reference to grazing, this being due to a great extent to the phenomenal growth of annual pastures during the

spring months. Quite a number of the competitors had left their irrigated pastures for hay, and consequently when the first application of water should have been given, hay was still on the ground. This caused a serious setback to the White Clover and meant a considerable opening up of the sward and the killing off of a number of the perennial grass species to occur. If farmers intend to cope with the prolific spring growth of these annual pastures by grazing, the irrigated fields should not be left for hay cutting, but should be cut early and conserved as silage. This operation would overcome the difficulties which follow hay making. Good recovery of the pasture species would occur before watering would be necessary. Consequently no opening up of the pasture would occur, thus preventing the entry of weeds and assisting in the checking of couch grass spread, all of which, if allowed, increase at the expense of the more valuable pasture species.

4. At the beginning of the competition the general application of fertiliser per acre was on the low side. Some farmers were applying as low as 2 cwts. per acre per annum. During the last year's inspection the fertiliser rates per acre used by the competitors varied from 3 to 7 cwts. per annum, applied in 2 to 4 applications, superphosphate being the principal fertiliser used. In one or two cases, however, small quantities of sulphate of ammonia and potassic fertilisers had been applied.

The amount of superphosphate required on irrigated pastures per annum has not as yet been accurately determined by this Department under our existing conditions. Experiments, however, have been conducted using rates from 2-7 cwts. per annum in applications varying from 1 to 5 during the season, a basal application of 2 cwts. in the autumn being given. The results of the experiment were not considered conclusive, but under irrigated conditions excellent returns have been obtained from applications of 6 cwts. per annum given in three dressings. The time of application is autumn and December to March inclusive prior to irrigation in the case of the summer application

So far as can be ascertained, from these experiments, no improvement or additional yield was obtained from those plots which had the spring application, together with the autumn application. Further experiments have now been designed and are under way to determine the effect of the varied rates of application, together with the varied time of application. On the experiments carried out at Roelands, the initial application of fertiliser on the area was in the vicinity of 11 cwts. per acre. It was found, when comparing the cost of the fertiliser with the production of butter-fat obtained over the whole area, that the cost of the fertiliser was 1.6d. per lb. of butter-fat. A competition carried out during the same year over a number of farms, showed that the average superphosphate application was in the vicinity of 2 cwts., the cost being 1.7d. for fertiliser per lb. of butter-fat produced. From these figures it will be seen that the high rate of application on the experiments, although considered far in excess of what the average farmer could afford, was no more expensive than the average application being put on, as both cost in the vicinity of 1.6d. per lb. of butter-fat produced.

The general recommendation for the irrigated pastures is an application of fertiliser, superphosphate only being recommended except in the initial years of establishment. The quantity used should be between 4 and 6 cwts. per acre, given in two or three applications, the heaviest application being applied in the autumn. Up to the present time no obvious response has been obtained from applications of potash, and in those places where lime and sulphate of ammonia have been applied to irrigated pastures, no benefit has been observed. This does not mean, however, that at some future time lime and potash may not become a factor in our fertilising programme.

Renovation.

The amount of renovation carried out on the pastures judged during the three years varied quite considerably. In a few instances no renovation had been adopted. Consequently, the pastures showed quite an amount of irregularity in growth, this being due mainly to the non-scattering of animal droppings. An important factor in irrigated pasture improvement is some form of mechanical renovation, the objects generally being threefold:

1. To aerate the soil.
2. To remove matted old grass and rubbish.
3. To enable fertilisers to come in contact with the soil.

The main advantage in the tearing up of the surface is the beneficial effect on the pasture, as it encourages the plant to produce fresh shoots and new succulent growth.

With reference to the sod type of pastures, more particularly paspalum, which often grow in irrigated areas, it is frequently noticed that unfavourable conditions for mixed pasture growth commence once the sward is well established, this being somewhere in the vicinity of four to five years after the initial establishment. In old, neglected paspalum pastures very little if any clover, and practically no paspalum growth is obtained. This position is brought about by dead root accumulation in the upper layers of the soil, which act as a thatch and interfere with the young roots and the aeration of the soil. To overcome this, it is necessary to use a good type of renovating implement. The use of chain or pasture harrows is also recommended during the winter months, this to spread and break up cow pats, which so frequently are seen on all types of pastures. Wherever these pats occur, rank growth of grass can be observed, and this is not eaten or relished by stock.

Irrigation.

All the pastures judged in the competition were laid out for watering by the furrow method. Some grading had been done but in the majority of instances the pastures had been sown on the most uniformly contoured portion of the farm without grading. The system generally adopted was the same as for irrigating potatoes and fodder crops. Under such conditions lateral seepage from furrows has been found to be reasonably rapid on account of the land having been freshly ploughed; but land laid out for irrigating pastures under such a system quickly becomes consolidated and compacted by the grazing stock and lateral seepage soon becomes too slow, with the consequent over watering of land adjacent to and along the furrows, while under watering occurs along the crown of the land.

At the time when these pastures were sown, however, there was little time and opportunity to do much grading, and under the circumstances it was the only system to adopt.

A power grader is now operating in the irrigation areas which is economically doing work which would not be feasible with teams on account of the high cost.

During the last two seasons, several hundred acres have been graded and land is being prepared for the control flooding of pasture under irrigation in all districts.

The system recommended is to lay the land out in long strips or borders at right angles to the contours so that the borders have a fall from end to end but are level sideways. The water is let out of the head ditch on to the surface of

the land and spreads sideways to the check banks, then slowly traverses the field from top to bottom. The borders, being laid out in the direction of the heaviest fall, provide the maximum run off for the heavy winter rains.

The following block shows the system in operation in the Collie Irrigation District.

Block showing border system of watering at Waterloo. Note water in the pasture.

Some Faults and Suggestions in Connection with the Grading of Potatoes.

E. T. MORGAN—Officer in Charge, Potato Branch.

This season (1939-40) has seen many condemnations of potatoes by reason of faulty grading. The faults complained of include second growth, greening by exposure and mechanical injury. The term "second growth" is understood by the majority of growers and is used to define tubers having abnormal malformation for the variety of potato. This so called second growth is generally manifested by protuberances or "knobs" generally from the original eyes of the potatoes, although it sometimes shows by elongation of the tubers with pronounced divisions of growth showing along the potato. These latter potatoes are often found in irrigated crops and show that the watering has not been carried out with due attention to maintaining an evenness of water supply. Again, it may be that unsuitable land for the growing of irrigated potato crops has been chosen. In the irrigation areas water is available only at certain set periods and land should be selected that will not tend to dry out during the periods between waterings.

Most growers would state that second growth is caused by weather conditions, i.e., by rains following dry periods during the time that the potato plants are nearing maturity and this is the generally accepted cause of the trouble.

There are, however, other contributing causes and these include Rhizoctonia and the over use of stimulating nitrogenous fertilisers. Regarding tubers from Rhizoctonia affected plants, the size of tubers and malformation of same will depend on the period in which the plants are most seriously affected. If such injury occurs in the early stages of growth, the tubers are generally small and malformed, but if, as is often the case, the attack is pronounced when the plant is nearing maturity, large tubers with much distortion are noted. It therefore behoves the grower to take such measures to control this disease as have been advocated by the Department of Agriculture for many years. The disinfection of seed, rotation of crops and the ploughing in of green material are effective in the control of the disease.

There is little doubt that much second growth, cracking and other malformation of tubers is caused by the too heavy use of nitrogenous fertilisers. It has been stressed on numerous occasions that the potato demands a well balanced fertiliser. Most of the mixtures that are quoted as potato manures are generally considered to be well balanced fertilisers.

It is usual in the growing of the spring crop in the South-West for growers to supplement the initial fertiliser mixture by top dressing the plants at emergence with sulphate of ammonia in order to replace some of the nitrates which may have been lost in drainage water.

The recommendation has been to apply 1½ to 2 cwts. of sulphate of ammonia per acre, but it is not unusual to find growers using from 3 to 5 cwts. per acre and in some cases applying a further dressing at a later period. These heavy dressings definitely lead to the unbalancing of the fertiliser mixtures and the results can be often observed in large ill-shaped tubers, caused by growth fluctuations of such treatment. The grower is ever chasing that 20 tons per acre crop, but if such is obtained with loss of quality the result is far from being satisfactory.

A further cause of so called second growth which has come to notice lately is evidently occasioned through extreme lightness of soil. This applies to new land in some of our very moist light peaty swamp areas. The potatoes are grown at a very shallow depth, almost in pure vegetable matter and such soil evidently does not offer sufficient resistance to expanding tubers and it has been noted that shape is detrimentally affected. There is of course little that can be done in such cases but as the land "settles down," correction of the trouble is to be expected. The rolling of the land may be necessary to allow of sufficient consolidation of the soil and slightly deeper planting may be advantageous.

Greening by exposure is a term with which most growers are familiar and it is a fault that all should take steps to obviate. Such potatoes are unfit for human or animal consumption, by reason of the poison solanin, which is developed by tubers in the process of greening.

There is little doubt that this greening can be avoided by attention to cultivation. Many of our so-called hill crop potatoes are grown in heavy soils and during wet weather conditions the soil is packed down by heavy rains, and as drier weather is experienced, much soil cracking by expanding tubers is apparent. Perhaps the tops have become too large, when weather conditions have been favourable, for effective horse cultivation, and the crop is left to carry on in its own way. Unfor-

tunately as the tops begin to die down the tubers that may have pushed their "noses" through the soil are deprived of shade and quick greening takes place. If sufficient width is left between the rows it is possible to carry out extra ridging or "moulding" at the period when the potatoes are nearing maturity with little or no injury to the crop, but with a definite saving from the viewpoint of quality; not only are the tubers protected from greening but also, to a great extent, from ready attack by potato moth larvae.

Mechanical injury is a term used to convey damage caused during the process of harvesting and generally applies to fork stabs. As well as fork stabs, such term is also used to define potatoes which have shown second growth and the protuberances or "knobs" have been broken off. In both cases the broken part of the tuber is liable under certain conditions to become invaded with various organisms (*Fusarium* and *Pythium* spp.) which will have the effect of causing rot in a very short space of time. So-called Watery Wound Rot (*Pythium de Baryanum*) will often cause tubers to completely collapse in 24 hours and it is not unusual to find that potatoes dug from peaty and other swamps during hot weather, which may be forwarded to market with every confidence by the grower as to quality, show a great deal of breakdown which has developed during transit to market. To avoid such trouble and the expense of picking over at the marketing end, it is advisable, if not possible to wait for cool conditions, to cart the potatoes from the paddock and regrade same after a week has elapsed. Tubers that are going to rot will collapse generally within a week of digging. Seeing that much damage eventuates from injury to tubers, regulations throughout the world are framed against such injured tubers being included in samples classed as Grade I. tubers.

The majority of our harvesting is carried out by fork digging and whether it is that the "good old type" of potato digger is dying out or the number of bags filled in a day is of greater concern, the result in many cases shows that the digger's work has not been carried out in a manner satisfactory to the grower who is paying him and who has to bear the brunt of his failure to do a job for which he is being paid.

Seeing that many growers have expressed dissatisfaction at results, it suggests itself that a remedy should be sought.

The alternatives seem to be (1) The tubers should be dug and afterwards graded; (2) The use of mechanical diggers. In America it appears that practically the whole of the potato crops are harvested and carted into sheds, where grading is carried out, on exactly the same principle that our fruit crop is handled.

Where an orchard has been planted, it is usual, as the trees near the bearing stage, for the orchardist to erect a shed for the purpose of handling his crop. I am afraid that many of our potato growers have no such facility for the handling of their crops.

The other alternative for lessening the amount of injury to tubers, is by the use of mechanical diggers. We know that such implements will not grade the potatoes, but the careful use of such implement will greatly minimise the injury to tubers. It is interesting to note that this year has seen great activity on the part of growers in the Albany area in the use of mechanical means for the harvesting of their crops and many farmers have expressed gratification at the work of the double mouldboard plough arrangement with the mouldboards replaced by prongs.

The failure to obtain satisfaction with such implement is of course reported (1) by reason of trashy ground; (2) over-wetness of soil and (3) many tubers being damaged.

It would of course be difficult to devise a machine which would operate under all conditions and when heavy weed growth has been ploughed in and decomposition has not been complete the attempted use of machinery is unsatisfactory by reason of "clogging." Over-wetness of soil may also act as a detriment but the cases quoted are rare, and judging by results witnessed this year, much can be said in favour of the mechanical type of harvesting. Injury to tubers is mainly due to the fact that the potatoes have been planted at varying depths and the set of the implement has not been able to cope with such varying conditions. There is little doubt if growers, contemplating the use of mechanical aids to harvesting, planted their crops with this end in view, that results would be satisfactory. Any mechanical digger operates most satisfactorily where the potato crop has been "moulded up" and such earthing up can be carried out as the crop is nearing a fit state to harvest. This method is used by Mr. F. V. Hortin of Hortin's Siding, who efficiently works an elevator type of digger.

It will, of course, be necessary to leave sufficient width between the rows for this operation to be carried out effectively. It is understood that top growth is often excessive, but it has been found that where such occurs, cultivation carried out when the tops are dry will allow the implement to travel between the rows without clogging, which will happen if the tops are moist.

Notwithstanding the foregoing, it is realised that the majority of the potato crop will be handled by fork digging, and it is suggested that, if growers wish to safeguard their interests in a greater degree, diggers should work under numbers.

This method is now being used by many growers, and if each digger's bags are numbered, it enables the grower to immediately designate the member whose grading is at fault. It is not unusual to find, in a truck of potatoes, bags which are in every way satisfactory, as to grade, while others leave much to be desired in this respect, plainly showing that the operations of certain diggers are not up to the required standard.

Potato grading regulations throughout the Commonwealth are asking for ever better quality and it behoves us to take the greatest care of our product so that it will compete more than favourably with that of other States.

REVIEW.

"Diseases of Poultry in New South Wales."

"Diseases of Poultry in New South Wales" by T. G. Hungerford, B.V.Sc., Government Veterinary Officer, Stock Branch, Department of Agriculture, New South Wales. New South Wales Department of Agriculture publication, 1939, *pp.* 230. *Price* 10*s.* 6*d.*

For some considerable time, in all progressive states and countries, it has been generally realised that diseases of poultry, no less than those of any other livestock, must be studied and dealt with along the accepted scientific lines applied by the qualified Veterinarian in meeting the disease problems amongst our larger animals. By virtue of his highly specialised training, which these days includes a full study of poultry diseases as far as they are yet known, the Veterinarian is the only one competent to deal thoroughly and efficiently with such matters and it is gratifying and timely to welcome the appearance of a publication by a Veterinarian who has for some years now, specialised in poultry work.

The author points out in his preface that the book "is not written as a technical treatise on poultry diseases" but it is "a popular account of symptoms, control measures, as well as an indication of what is still unknown concerning some

of the disease conditions." He goes on to state that "those who have only a passing interest in disease may find that the amount of detail given is somewhat irksome. This has been done intentionally, as a passing interest which leads one to make an ill-founded diagnosis and to carry out incorrect treatment will usually demonstrate that 'a little knowledge is a dangerous thing.'"

Although the title is "Diseases of Poultry in New South Wales" it will be found equally valuable under Western Australian conditions as there is no disease yet diagnosed here with which the book does not deal. Infectious Laryngotracheitis and Fowl cholera which are dealt with at some length have not yet been detected in this State.

If the publication only succeeded in teaching the poultry farmer to cease using the misleading and all embracing term "roup" and that medicinal treatment for infectious poultry diseases is seldom worth the trouble and expense involved, then it would have accomplished a good deal. The term "roup" is far too commonly used here and scarcely any farmer yet realises that it comprises five entirely different diseases of different cause, as well as several more obscure ailments. There are still many who will treat Avitaminosis A (green feed deficiency disease) with eye lotions and Coryza or Infectious Catarrh with medicated water.

This book deals with 74 different conditions of interest to the poultry farmer without any important omissions. For the purpose for which it is intended we feel that it is worthy of recommendation and except when dealing with the Leucosis group of diseases it is written in a style which the farmer will not find difficult reading.

L. W. MAHAFFEY.

White Clover,

by

H. G. ELLIOTT, Agrostologist.

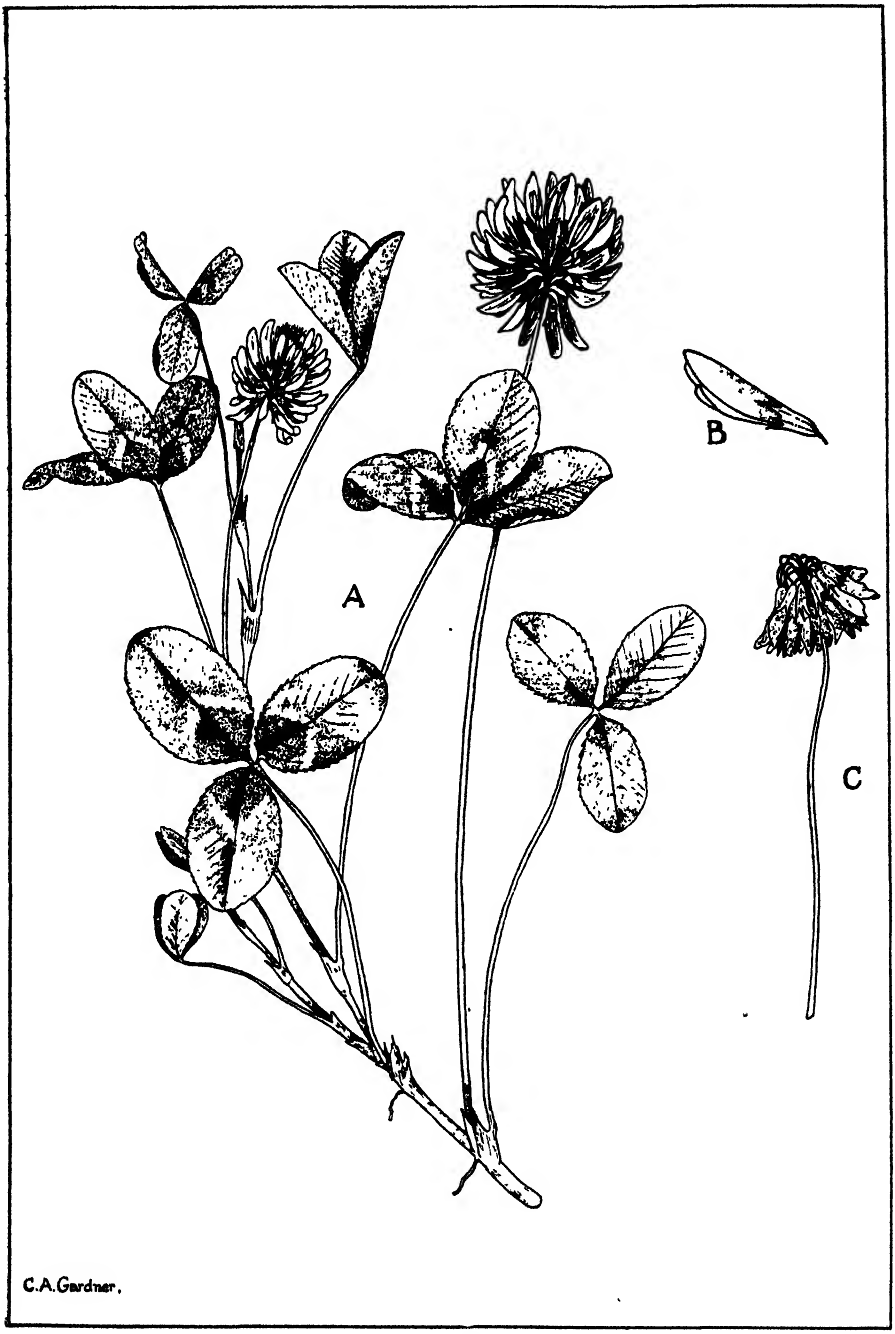
White Clover (*Trifolium repens*) has become a pasture legume of first importance in the irrigation areas of this State which extend from the Waroona district to Dardanup. This clover is also of great value on certain soil types along the south and south-west coastal regions.

White clover is indigenous throughout temperate Europe and Asia and the first seed was harvested in Holland, hence the name of that type today "White Dutch Clover."

*Description of Plant.**

"A hairless perennial with prostrate rooting stems. Leaflets (3) broadly ovate and usually marked with a crescent shaped white stripe. (See illustration). Finely toothed margins but veins not very conspicuous. The flowers are white, but are pink when in bud and are loosely arranged in a head consisting of usually 30-40 flowers. The stalk of the head is generally longer than the leaves. Pedicels short and slender, reflex after flowering. Calyx glabrous ten-nerved with acute teeth usually erect. Standards twice as long as the calyx. Pod enclosed within the calyx oblong, slightly constricted between the three or four seeds."

*Description given by Mr. C. A. Gardner, Government Botanist.



White Clover.
(*Trifolium repens*, L.)

***Explanation of Plate*:**
A.—Plant. B.—Flower (enlarged). C.—Fruiting head (enlarged slightly).

White clover is generally a fairly, and often a very long-lived, perennial. It forms a well developed mat of fibrous roots. Unlike Red and Alsike Clovers, it has solid stems which creep on the surface, rooting at the nodes so that the plants are able to colonise the ground freely by means of vegetative reproduction. Except under certain conditions it is not general for white clover to produce abundant top growth, consequently when cut for hay or silage the material consists almost entirely of leaves and flowering heads.

Strains.

A considerable number of forms or strains of white clover are to be found. These do not differ from each other in well marked characteristics. During the last ten years the value of strains in pasture grasses and clovers has received much scientific investigation and general recognition. The difference between variety and strain could be summed up as follows: Variety possesses structural variations, such as in the flowers or structural difference of the leaves and branches which makes it different from the original species type. A strain, however, has variable characteristics such as early or late flowering, long or short growing period, high or low production, variability in leaf denseness, steminess, etc., which are ascertained when carrying out comparative field tests. From an agricultural point of view, however, it is possible to make the following classifications:—

(1) White Dutch Clover of Commerce.
(2) New Zealand White Clover.
(3) New Zealand White Clover Government sealed and certified Permanent Pasture.
(4) Victorian Irrigation White Clover Dingee Government sealed and certified.
(5) Kentish Wild White Clover.
(6) Ladino Giant or Mammoth White Clover.

(1) *Commercial White Dutch Clover.*—This is grown for seed in Central Europe, Russia, Holland, Britain, Poland, Denmark and America. In general, much of this commercial seed does not give rise to a long-lived plant, and frequently only produces plants of biennial duration. This type generally establishes itself freely from seed, and is fairly productive during the first season. It flowers profusely during the first summer after the sowing, and normally early in the season. The leaves are of medium size and it is generally claimed where severe winters occur that it is a type which is a poor winter grower.

(2) *New Zealand White Clover.*—In characteristics, much the same as the Dutch type, except that it appears to be more vigorous and probably more persistent. This may be due to the inter-crossing of the ordinary imported type with the more productive and permanent white clover type.

(3) *New Zealand White Clover Permanent Pasture.*—Comparatively large-leaved, highly productive, widely spreading type, with stout runners, being dense and persistent. A good winter growing form, vigorous in the spring and holding well in the summer and early autumn.

(4) *Victorian Irrigation White Clover Dingee Certified.*—Comparatively recent introduction in this State. Experiments with this type indicate that it is slightly superior to the New Zealand permanent pasture type, being more vigorous, larger-leaved and producing a greater bulk of green material under irrigated conditions.

(5) *Kentish Wild White Clover.*—Similar in characteristics to the White Dutch type. The plant is very much longer lived and a more hardy perennial with a close creeping habit, producing numerous abundantly rooted runners, which carry large numbers of small leaves on fairly short stalks. Its flower-heads are fewer per plant and often smaller, and its seeds usually smaller and plumper than those of the White Dutch type. This clover is indigenous to Great Britain.

(6) *Ladino Giant or Mammoth White Clover.*—This type originated in North Italy. It is probably the tallest growing and largest-leaved white clover in commerce. The plant is lax in growth and it does not persist well.

Agricultural Uses.

Generally speaking, the ordinary commercial white Dutch clover should only be used in rotations, or as a constituent in mixtures sown for a two or three year duration, while the New Zealand white clover of permanent pasture origin and the Victorian irrigation white clover should in all cases be the types used in mixtures being sown for a permanent pasture. Of the six types given above, only two are grown to any extent in this State. Till recent years, the dominant types sown were the commercial Dutch and New Zealand white clover. Today, however, the type recommended and mainly sown is the New Zealand certified permanent pasture type. Neither the Kentish wild white nor the Ladino or Mammoth white are grown, but during the last season, some interest has been shown in the Victorian irrigation dingee type, owing to results which have been obtained in plot and field trials.

Where to Sow.

The areas recommended for the sowing of white clover, either alone or in mixtures with other clovers and grasses, are those where irrigation can be practised or in the high rainfall areas on soils which are comparatively well drained but retain their moisture during the summer months. These areas are often found in the Denmark, Manjimup and Margaret River districts. White clover is recommended as the standard legume constituent of our irrigated pastures. During recent years in our irrigation areas we have found that it will grow and thrive well on freshly graded land, and also is capable of establishment on new land, provided that the necessary bacterial inoculation has been given to the seed prior to planting. Experience has shown that this clover does well on a variety of soils, ranging from heavy clays to the lighter loam and in the higher rainfall areas on sandy and peaty types of soil. Particularly satisfactory results, however, are obtained on the medium and light loams.

Where lucerne flea and red mite infestation is high, it is not recommended that this clover be sown during the autumn months. Spring planting or early or late summer plantings are recommended, so that the young seedlings will have a chance to grow without suffering from the effects of these two pests.

It is also important from the point of view of keeping out weeds, that white clover should be established quickly, and as regards the fertility of the ultimate pasture, a relatively high content of white clover in the sward is advantageous, as it assists in building up the fertility of the soil. It has also been shown that the leaves of the plant are rich in both protein and calcium, so that a good proportion of white clover in a grass sward adds to its nutritive value.

Time of Sowing:

As stated previously, it is not recommended to sow white clover in the autumn, unless on new land or land which has been freed to some extent of Lucerne Flea and Red Mite. Under irrigated conditions, it is recommended to sow in the late

spring or early or late summer, so that establishment will be obtained prior to the ravages of the Lucerne Flea and Red Mite commencing. When sown in the early or late summer, it is necessary to carefully water by irrigation at about ten day intervals, until the plants are able to withstand longer intervals between watering, up to three weeks.

Cover Crops:

From experiments which have been conducted in the irrigation area, it has been definitely shown that quick growing cover crops are detrimental to the early establishment of white clover. Such types of cover crops as Millet, Sudan or Oats do have the effect of suppressing the young white clover seedlings, and consequently, it may be upwards of two years before a full cover would be obtained. In the interim, however, weeds such as couch grass are liable to take charge of the area at the expense of the white clover. In some cases, where high rates of seeding with Ryegrass have taken place in mixtures in which white clover has been incorporated, much slower rate of establishment has been obtained, and in many cases up to two or three years elapsed before a reasonable ground cover of white clover occurred. Consequently, it is not recommended that any form of vigorous growing cover crop be used when establishing pasture in which this plant is a constituent.

Mixtures and Rate of Seeding:

It is usually recommended that white clover be planted in association with Ryegrass and Cocksfoot, or Ryegrass and Paspalum. In some instances, however, pastures of two species are established, these being ryegrass and white clover or *Phalaris tuberosa* and white clover. In all cases it is recommended that no more than 2 lbs. of white clover seed be used, providing reasonable attention and care has been given to the preparation of the land. For obtaining information as to rates of seeding, etc., Leaflet No. 601 on the "Sowing of Pasture Seeds" can be obtained.

Method of Seeding:

Results have shown that for the best results the seed should not be sown to a greater depth than ¼ to ½ inch. The usual method recommended is to sow this seed in a finely worked seed-bed in combination with the other seeds in the mixture, the area to be rolled after seeding, or very lightly harrowed. Whatever system is adopted, it is advisable to use a brush-harrow afterwards. The soil cover of the seed is beneficial, but not absolutely essential, as this clover is one of the few which will germinate and grow without soil covering. In order to spread the seed evenly, it is recommended that a small seed sower, such as the hand seed sowing types of machines be used. If these are not available, and providing the seed is not mixed with the fertilizer too long prior to planting, the seed can be distributed evenly by any fertilizing machine. Where inoculation of the seed is being carried out, it is not recommended to broadcast the seed in combination with the superphosphate.

Inoculation:

As is the case with other plants belonging to the Legume family, white clover has the ability to use atmospheric nitrogen for growth, but only when the proper bacteria, which vary for different groups of plants, are present. In some cases, however, when white clover is planted on old land which has grown subterranean clover or other annual clovers of the *Trifolium* species, inoculation may not be required, and in many of the districts in the irrigation areas, inoculation is not

practised, but where new land, or freshly graded land is being sown to White Clover, inoculation prior to planting is essential. For this purpose, bottles containing bacteria for inoculation together with directions for use are provided by the Department of Agriculture at a nominal cost. Seeds, once they are inoculated, should not be mixed with superphosphate prior to planting, as it has been shown that the superphosphate injures the bacteria. For best results, however, it is essential that the inoculated seed be sown at the same time as the superphosphate, but where no contact is made. When sowing this inoculated seed, it is essential that the ground should be wet at the time of sowing.

Fertilizer.

For best results, fertilizer in the form of superphosphate is essential to the success of this clover. The superphosphate should be applied at the time of seeding, at a rate of 2 to 3 cwts. per acre, and at regular intervals thereafter. When white clover is established, the best time for the application of the superphosphate is early autumn, i.e., April, at a rate in the vicinity of 2 to 4 cwts. per acre. This heavy rate of fertilizing in the autumn appears to give the most economical results. Further applications of 1 cwt. per acre can be given in November and February, prior to irrigation.

Management.

One of the important phases of an irrigated pasture is the control to some extent of white clover. A dominantly leguminous sward presents some difficulties. During the irrigation season this clover provides the bulk of the herbage over an extended period, and with the attention paid in recent years to the watering and top-dressing, white clover has to some extent been encouraged to the point of nearly excluding all the other species, with consequent difficulty in maintaining a good grass-clover balance. For some time it has been observed that in a mixed pasture the grazing system employed profoundly influences the balance of the various species. The general aim should be to retain a desirable balance between the species, and particularly between grasses and legumes. This should

Block showing a pure stand of White Clover, New Zealand certified type, grown under irrigation at Brunswick.

result in a better production throughout the year, and further the herbage in a well balanced sward should be more palatable. During the first year of establishment, care has to be taken not to over-graze the white clover; quick grazing with a number of stock at intervals sufficient to allow the clover to recover and produce reasonable top-growth should be practised. After the first year of establishment, experiments have shown that the best method of maintaining the clover in association with such grasses as Cocksfoot, and Perennial Ryegrass, is to ensure that the grazing periods are not closer than approximately 21-day intervals. During the cold and wet portions of the year, this period may have to be extended to 30 days. Where severe over-grazing occurs, more particularly during the summer months, there is a tendency for the pasture to become open, allowing an increase of weed species.

On old paspalum fields, which have become practically non-productive owing to being root-bound, the introduction of a suitable legume is essential. For this purpose white clover can be used. It is recommended that the paspalum be ploughed with a mould-board plough and after the surface has been worked down, white clover at the rate of 2 lbs. per acre and perennial ryegrass at 4 lbs. per acre be introduced. This method has been adopted on a number of fields in our irrigation areas with success.

Summary.

From the foregoing, the following may be summarised as of first importance:

(1) Of the types of white clover, the seed of which is available, the New Zealand certified permanent pasture white clover and the Victorian certified irrigation white clover are recommended for use in permanent pastures.

(2) White clover has demonstrated its ability to produce better than subterranean clover under irrigated conditions.

(3) Inoculation is essential on new or graded land.

(4) Shallow sowing is desirable.

(5) Dense, heavy producing cover crops are detrimental to the initial establishment of white clover.

(6) It is not recommended to exceed more than 8 lbs. per acre of Perennial Ryegrass when sown in association with white clover.

(7) Under irrigated conditions, high rates of superphosphate applications per acre are profitable.

(8) The proportion of clover or grass in the pasture can be affected by the grazing management.

Ragwort.

(Senecio Jacobaea L.)

A NEW NOXIOUS WEED.

C. A. GARDNER.
Government Botanist.

The importance of the early recognition of a serious weed, and its prompt destruction has been demonstrated very clearly in the case of ragwort in Western Australia. In January of this year a specimen of ragwort was received at the State Herbarium from the secretary of the Manjimup Road Board, who stated that Mr. J. J. Mottram noticed an unusual plant on his holding, and, suspecting that it might be a weed of some consequence, had handed a specimen to him to be forwarded for determination. This specimen was the first record of ragwort in Western Australia. An officer immediately visited the district to investigate the reported occurrence, and found that the affected area comprised about one hundred square yards in a pasture paddock where the large trees were dead but still standing. The plants of ragwort were mainly clustered together and had the appearance of having originated from a single, or but few associated plants.

The history of the occurrence of the weed suggests that the seed was introduced from New Zealand, together with the seeds of pasture plants from that source, about five years previously. The prompt recognition of a weed by Mr. Mottram, and the interest and co-operation of the road board, have resulted in what is hoped will be the suppression of this plant in Western Australia. Specimens of the weed were deposited with the secretary of the Manjimup Road Board for exhibition, in order that the plant might be recognised by others. The result was the detection of another small occurrence on a property not far removed from the original area.

Ragwort has been proclaimed in the *Government Gazette* as a noxious weed for the State of Western Australia, and the two known affected areas have been grubbed. A close inspection of these spots will be maintained at intervals, and settlers, especially those in the Denmark-Northcliffe districts, are urged to be on the look-out for the plant.

Ragwort is a perennial herb native to Europe, Siberia and North-Western India, but is recorded as a naturalised alien in North America, New Zealand, and Victoria. It is toxic to stock. In New Zealand large areas have become infested—in places to the exclusion of most other vegetation .

In addition to the fact that ragwort is a robust perennial capable of reproducing itself vigorously from its roots, it is also a remarkably free-seeding species adapted for rapid proliferation. The seeds may lie dormant in the soil for some years, and germinate when conditions prove favourable. It is because of this latter characteristic that some years must elapse before complete extermination can be claimed with certainty.

Toxicity.

Ragwort has been proved toxic in Britain, in Canada, New Zealand and Victoria. Horses and cattle are most likely to be affected, and the slow poisoning of dairy cattle has caused much concern. The toxic effect is cumulative. Poisoning under natural conditions is a slow process because an animal does not usually eat enough of the weed at one meal to cause acute poisoning; on the other hand, through its cumulative action the amount of poison which becomes available is sufficient in time to cause very serious symptoms which often end in death.

Murnane* states that after grazing for twelve months or more on areas where ragwort is plentiful, cattle develop typical symptoms, exhibiting dullness, loss of appetite, and a jaundiced condition of the eyes, together with a peculiar staring appearance. There is loss of weight and, in the case of lactating animals, a very marked diminution of the milk supply. The milk has a peculiar odour and a pronounced acrid flavour rendering it quite unfit for use. The affected animal frequently exhibits a scabby condition of the skin, especially in the udder and teats. In the later stages there is impaired vision, staggering gait, persistent diarrhoea, a marked thirst and progressive loss of condition. The milk supply ceases, food is not taken, the animal becomes weaker, drops down and eventually dies—frequently in a swamp or water hole into which it has wandered in order to quench its insatiable thirst.

The actively poisonous agent in the plant appears to be one of two or more alkaloids which have been extracted in more or less pure form from various species of ragwort. It would appear that, although animals which had received a toxic amount of ragwort over a certain period, may seem healthy at the time when feeding on the material is discontinued, they nevertheless develop acute symptoms of poisoning and die at a later period. Thus, in cases investigated in Britain some of the animals did not show definite symptoms until twelve days or more after feeding tests with ragwort had been discontinued.†

There is no cure for ragwort poisoning, and prevention resolves itself into the eradication of the plant. Sheep are less affected than cattle and horses, and when managed correctly provide a practical measure of control.

Eradication and Control.

The prevention of seed-formation on the plants is a very important factor in the control of ragwort. Where only a few plants occur, careful grubbing represents the most safe method of control The roots and the entire rootstock should be removed, heaped and burned, this operation being carried out before the flowers have expanded, since any flowers present on severed plant parts may develop mature seeds because of the sappy nature of the stems; consequently every part of the plant should be destroyed.

Since the seeds retain their vitality in the soil for a number of years, one year's seed production will necessitate a careful examination of the infested area for several years after grubbing. Spasmodic cultivation only serves to divide the rootstocks and spread the weed. Any cultural work must be thorough and repeated as often as necessary, and it is important that the affected area should be treated as a unit in this connection.

Where the plant is abundant and widespread, sheep have proved a practical means of control. This method has been attempted in many places in New Zealand with success and has resulted in practically no abnormality amongst the sheep, but, on the other hand, mismanaged efforts on the part of other settlers have resulted in failure with heavy stock losses. Given proper treatment, a measure of control has been secured in two or three years. Very good results have been achieved by stocking heavily with sheep when the ragwort is young and juicy. Small paddocks are desirable, and old animals have been found to be less affected than lambs, and at the same time more severe in their grazing.

Both sodium chlorate and arsenic pentoxide have proved effective when sprayed on ragwort, complete destruction having been obtained from the application of a five per cent. solution of sodium chlorate. This treatment by sodium

* Ragwort Poisoning in Cattle in Victoria—W. Murnane, Journ. C.S.I.R., Vol. 6, pp. 108-110.
† Report of the Board of Agriculture's Chief Veterinary Officer (1917).

EXPLANATION OF PLATE.

A. Habit of plant showing stock and basal leaves, also the apical portion with stem leaves and flowers. About sixteen inches from the middle has been removed. B. Stock with a rosette of basal crisped leaves. C. Radical leaf. D. Flower-head. E. The same showing the involucre of black-tipped bracts. F. Disc floret. G. Ray floret. H. Fruit ("seed").

Northcliffe, W. Australia. January, 1940.

chlorate has proved more effective during showery weather than during particularly dry weather, and Dean* states that as the plant reaches the flowering condition a weaker solution than that required while the plant is actively growing may be used. An application as low as two per cent. has proved effective when applied to plants in flower. The chemical control of weeds is, however, an expensive method, and usually is not economical for large areas.

Description of Plant.

Ragwort grows to a height of from two to three feet, from a short thick rootstock which divides with age. The stems are strictly erect, simple or branched above, and usually a bright purple in colour. Leaves pinnate, with ovate, obovate or narrow coarsely toothed or pinnatifid segments, the terminal ones large and confluent, the lower smaller, all glabrous or loosely downy, especially on the lower surface; basal leaves on long petioles, the uppermost sessile. Flowers yellow, in compact or broad terminal corymbs; involucral bracts linear, tipped with dark brown or black points, the outer bracts few and very small. Ray florets yellow, usually 12 to 16 in number, linear-oblong, spreading; disc florets numerous, yellow. Achenes of the disc florets shortly and coarsely hairy, the achenes of the ray florets glabrous.

For further particulars see the accompanying plate. The young plants have dense crisped radical leaves and the thick stock develops early, the stems in the local plants are purple in colour.

* Control of weeds with chlorates—J. W. Dean, New Zealand Journ. of Agric., Aug. 20, 1931.

Agricultural Problems.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser or Veterinary Officer of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—

Albany	A. T. Gulvin, W. R. Jamieson (Fruit).
Bridgetown	A. M Tindale (Dairying), A. Flintoff (Fruit).
Bunbury	M. Cullity (Dairying), A. F. Flood (Stock Diseases).
Busselton	J. M. Nelson (Dairying).
Denmark	C. W. Tobin (Dairying).
Geraldton	N. Davenport, c/o. Government Buildings.
Gosnells	R. C. Owen (Fruit).
Harvey	R. C. Cailes (Fruit).
Katanning	A. S. Wild.
Kalamunda, Roleystone ..	W. H. Read (Fruit), c/o. Dept. of Agriculture, Perth.
Kununoppin	W. M. Nunn.
Manjimup	J. T. McNally (Dairying).
Margaret River	A. L. Hamilton (Dairying), R. Harley (Stock Diseases).
Metropolitan, Gingin, Chittering	S. E. Bennett (Fruit), c/o. Department of Agriculture, Perth.
Moora	G. L. Throssell.
Mundaring	V. Cahill (Fruit).
Pemberton	C. M. Scott (Dairying), Manjimup.
Pinjarra	B. Williams (Dairying), c/o. Department of Agriculture, Perth.
Waroona	A. H. Hobbs (Dairying).

Lucerne Growing in Western Australia,*

by

H. G. Elliott, Agrostologist.

Summary.

(1) Lucerne has been grown for many centuries, and consequently is well known in most of the agricultural countries of the world. As far as can be ascertained it was introduced into Australia just after the first settlement by white man and since that time has made considerable progress.

(2) Lucerne flourishes in semi-arid climates, but for maximum growth requires abundant water during the summer months. Consequently, it grows best where supplemented with irrigation.

(3) Of the many varieties of Lucerne, the most important in Western Australia are:—

Australian Hunter River.

Californian.

Hairy and Smooth Peruvian.

(4) For best results only high quality seed should be used.

(5) Lucerne has many peculiarities and troubles, being somewhat delicate when young, and of all crops is the most sensitive to competition from other plants, consequently the secret of success is to keep down weeds during the first year.

(6) Lucerne will not tolerate soils which become water-logged.

(7) This plant does not need, as many assert, abundance of lime in the soil, but freedom from acid is essential. Soils that are deficient in lime, however, should receive applications of agricultural lime prior to the planting of the lucerne.

(8) Innoculation of the seed with the necessary nitrogen-fixing bacteria prior to planting is essential.

(9) The ideal seed-bed for lucerne should be firm, but with a fine tilth to a depth of about 1½ inches.

(10) The best fertilizers are superphosphate and potash, the rates of application per acre varying according to districts.

(11) The land must be clean, for weeds are difficult to eliminate once the crop is sown.

(12) The best method of seeding is by drilling the seed into the land, but the seed should not be sown to a greater depth than ¾ inch.

(13) The best time to sow in this State is in the autumn or spring. In the south-west, spring is probably the best time, as it allows time for the control of Lucerne Flea and Red Mite, and late cultivations to kill weeds.

(14) According to districts and methods of planting, the seeding rates vary from 2 lbs.-12 lbs. per acre.

(15) Cover or nurse crops are not recommended or required.

(16) Farmyard manure stimulates lucerne, but should always be well rotted prior to application.

* Revised from an article on "Lucerne, The Queen of Fodder Crops," by G. L. Sutton, late Director of Agriculture, which appeared in Vol. 14, Second Series, No. 1, March 1937 issue of this Journal.

(17) When seed is sown in drills, the width between drills is determined by the weed difficulty. In the wheatbelt normal drill widths are recommended. In the coastal areas 24 to 30 ins. between drills is advisable.

(18) If the first year stand is thin, the weak patches should be re-seeded while the plants are young, otherwise it is difficult to make an even stand.

(19) Lucerne produces very heavy crops of fine textured forage, rich in protein, lime and other minerals suitable for all classes of live-stock.

(20) For best results from good stands of lucerne, it should be cut and not grazed. Under this system of management the stand will persist much longer.

(21) Experience shows that the plant, once established, can be heavily harrowed and cultivated to reduce weeds and mulch the surface soil.

(22) The time to cut lucerne for hay is when the new shoots have started from the crowns. This usually coincides with the flowering period.

(23) Lucerne leaves have a much higher value than the stems. Consequently great care should be taken, when making hay, to ensure that all the leaves are saved.

Introduction.

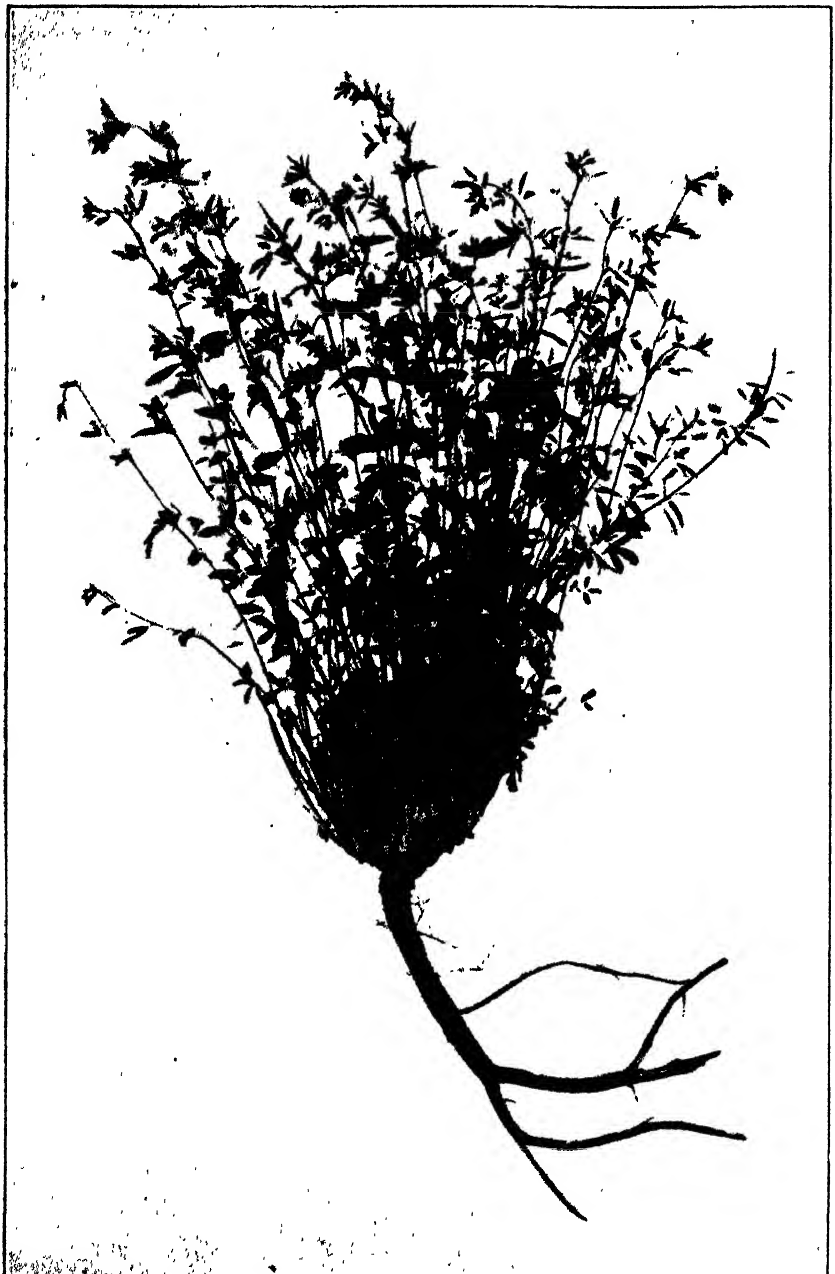
Lucerne is one of the oldest of the cultivated forage plants, and is one of the most important agricultural crops known to man. It flourishes in semi-arid climates, and although it gives best results where ample water is available, it can however, grow well wherever cereals are profitably produced in these climatic conditions. Besides being one of the hardiest of the known agricultural crops for hot dry conditions, it is one of the most palatable and nutritious foods for livestock, including all farm animals and birds, as they can maintain themselves and thrive on it. The crop has been cultivated for centuries in the semi-arid portions of Asia, as well as in parts of Europe, and in all places it produces an abundance of fodder of the highest quality, improves poor soils and assists in eradicating weeds. This plant can be successfully grown on a variety of soils, which range from loose sands to relatively heavy clay loams.

History.

Lucerne has been cultivated for thousands of years, and was introduced into Greece during the Persian Wars (about 490 B.C.) to provide forage for horses and cattle of their armies. It was taken to Spain with the Moors under the name "Alfalfa." The Spaniards introduced it to Mexico and from that country it spread over South America and extended to the United States and Canada. In Canada and America lucerne is known and cultivated as "Alfalfa." This word is believed to be of Arabic origin, and derived from words which mean "the best fodder." It will thus be seen that its great value for fodder purposes has been long recognised, and the splendid reputation which this plant so early earned and which by its name has come to us down through the centuries, is still maintained.

It is thought that the name "lucerne," by which it is known in England and France, was derived from the Swiss canton of the same name, but Coburn in "The Book of Alfalfa" considers this to be a mistake, as it was not known there until long after it was cultivated in France and England. He states that "the name 'Lucerne' is probably derived from the Spanish word 'Userdas,' which the French changed to 'La cuzerdo' and later to 'Luzerne' and still later to 'Lizerne' and then to 'Lucerne'."

Lucerne was probably brought to New South Wales by the earliest military settlers, but here, as in other parts of the world at that period, the difficulties in the way of successful culture were extremely great, and as early as 1806 the crop



Australian Lucerne.—Typical plant of Australian Lucerne, showing erect growth, strong stems, freedom from excess branching, and vigorous rooting system.
—Photo: W. J. Spafford.

was referred to in a report by Governor King, wherein he stated: "Lucerne grows extremely well, surviving at least three cuttings a year, but as it requires so much care and attention to keep it in tilth, and will not admit of being fed off, but few cultivate it."

At first, the progress the crop made was slow, but there has been a progressive advancement in the area seeded to lucerne, and in the last decade this has been really rapid, and it is inevitable that it will become increasingly popular as time goes on, in this State.

Description of Plant.

Lucerne (*Medicago sativa*) is a perennial plant belonging to the family of *Leguminosae,* of which it is probably the best known and most valuable member. The plant is either covered more or less with soft hairs, or is smooth. It grows from 1 ft. to 3 ft. in height, producing fairly upright stems, with many branches and much foliage. The stem originates from the crown at the summit of the tap-root, which is situated above or at the surface of the ground. The leaves, which are arranged alternately on the stems, consist of three leaflets, which in all types are wedge-shaped, but vary considerably, some being relatively long and narrow, whilst in other varieties they are short and rounded. All leaflets are toothed at the summit. The flowers, which in different varieties may be any shade of violet, from very pale to a deep reddish purple, are typically pea-like in shape, though much smaller, and are arranged in loose clusters at the summit of each branch. There are from two to six kidney-shaped seeds of a yellowish green colour in each pod, and they are about ⅛ inch in length, the pods being spirally twisted in two to four loose coils, open through the centre. It is a deep-rooting, remarkably long-lived and prolific perennial. Under the best conditions it may be cut many times a year, and year after year. It has been stated that there are lucerne fields in Mexico over 200 years old, and there are in France fields which are known to have

Lucerne Crop.—Showing stand of typical Australian Lucerne.

—Photo: W. J. Spafford.

been in production for over a century. There is no reason to believe that it will not be equally long-lived in Australia, if established on suitable soils, efficiently manured and given reasonable attention.

The tap-roots of the lucerne plants penetrate readily to 10 ft.-20 ft., and have been traced to much greater depths. Lucerne roots have been found 30 ft. below the surface of the alluvial flats of the Hunter River. Coburn records a case where the roots were found penetrating through crevices in the roof of a tunnel 129 ft. below the surface of the lucerne field. This extraordinary growth of the roots of a plant which normally does not exceed 3 ft.-4 ft. in height, shows that there are often differences between the habits of lucerne and other cultivated plants, and this points to the advisability of giving careful consideration to the soil conditions before attempting lucerne cultivation. It will go down to food and water if it can, and it is the farmer's business to see that it can.

It can be stated that lucerne is one of the hardiest of the cultivated crops. Where dry and hot conditions prevail it will produce more growth than any other known perennial plant. Except at the time of seed germination, lucerne does not require much moisture near the surface, and flourishes with sunshine in hot summer temperatures. For most prolific growth, lucerne requires a well-drained deep soil, which is not acid and contains plenty of moisture, either supplied from underground, or supplemented by irrigation, ample phosphatic fertilizers, and thorough cultivation during the life of the crop.

Climate.

Lucerne loves heat and makes its maximum growth in the spring and summer. It is at its best with plentiful supplies of water in combination with heat. Under such conditions, which in this State usually involve irrigation, it is remarkably prolific, successive cuttings of luxuriant forage being obtained at intervals of five to six weeks with an aggregate yield per acre of 20 to 25 tons of green fodder, or if made into hay of 6 to 8 tons. Owing to its deep-rooting system, it is well able also to withstand extremes of temperature. It is well adapted to withstand summer drought. The most favourable climates, however, are:

1. what has become known as semi-arid,
2. sub-tropical,

and in these climates, when sufficient water is available and good management is practised, lucerne gives its maximum return. Grown experimentally without irrigation at the Chapman and Merredin Research Stations, it has proved that it will live for several seasons through the dry summer, remaining dormant during the dry portion of the year awaiting summer showers or the winter rains to spring into activity.

It is believed that there is no part of the agricultural area in which this plant cannot be made to serve some useful purpose. For maximum returns for fodder or hay, irrigation will probably be necessary in most districts, with the exception however, of our lower south-west. In the dry areas, however, sufficient information is available to indicate that it is likely to prove useful for grazing.

Soil.

Except under adverse conditions, lucerne is not particular as to soil. With suitable treatment it will grow on almost all classes from nearly pure clay to light, sandy soils. At one time it was thought that it would only grow on rich, deep, alluvial types, but experience has shown that there is hardly any kind of soil on which it will not grow providing it is not acid or water-logged. The most

favourable one is a rich, somewhat sandy loam, warm and friable. The highest yields are obtained with the least trouble on the very best alluvial soils, found on creek and river banks, well supplied with plant food, and with free water from 6 to 20 feet below the surface. At one time, heavy clays were considered unsuitable, but cases are recorded where excellent crops have been raised on soils of this character. However, more care is required in preparing the seed-bed than on friable loams.

While lucerne can utilise enormous quantities of water during the growing period, it is killed by stagnant water lying upon it. A case is known, however, where the flood waters from the Hawkesbury River remained on a lucerne paddock for 8 days during the winter when the roots were partially dormant, and they did not do any permanent injury. In this instance, the deposits left around the plants were removed as soon as the water receded. Under Western Australian conditions many types of land are used for the cultivation of lucerne, but generally all farmers realise the value of alluvial soils and loams, preferably those which are fairly well supplied with lime. Lucerne has been known to send its roots 10 to 20 feet below the surface on dry lands. Under certain favourable conditions, the underground water may supply all the needs of the crop. It must be remembered that once the roots have penetrated to the water table, a sudden rise in the water table may seriously affect the ultimate stand of the crop.

Good drainage is the essential requirement of the lucerne plant, and waterlogged soils are useless for the crop. In naturally wet land, or land made so by the incorrect use of irrigation water, lucerne is very apt to take on a sickly yellow appearance. Under these conditions, weeds will become a severe competitor with the lucerne crop. It is well to remember that lucerne will not stand wet feet. Consequently, if the soil is not naturally drained to a depth of several feet, action must be taken to bring about this condition before the lucerne is planted.

Preparation of the Seed-bed.

Lucerne likes a compact, well prepared seed-bed with just a little loose soil on the top. Although lucerne, when established, is one of the hardiest of plants, yet when young it is delicate, and requires favourable conditions for its support. In some of our drier areas it has been found that a cloddy surface seed-bed is advantageous when establishing young lucerne plants, more particularly where spring planting is adopted. Under general conditions, the seed-bed should be warm, mellow and compact, with just a thin layer of loose soil on the top. It is essential that it be compact, in order that the seed may germinate readily and the soil moisture move most freely in all directions to convey the necessary nourishment to the young plantlet. The compact soil in which the seed is deposited should be covered over with a layer of loose soil, thin enough for the small and tender plant to force its way through, so that the evaporation of the moisture brought near the surface by the compaction of the under layers for the use of the roots, will be lessened. Because of these requirements, it is generally advisable to commence the preparation of the land some time before sowing, usually by fallowing and the plowing can then be deep. Except in rare instances the plowing should not be done later than at least six weeks before the seed is to be sown, for if plowed later than this, it is difficult to get the seed-bed into that compact condition which is so essential for the best results in the establishment of this crop. The planting of the seed in a loose seed-bed is a frequent source of failure with a lucerne crop. It is also desirable to have the seed-bed very free from weeds and weed seeds, as these are a big problem in the establishment, for they will often kill or smother young lucerne seedlings, owing to the slow initial growth of the latter. This

condition is the most frequent cause of failure of young lucerne stands. Where autumn planting is carried out, it is necessary that the land be properly bare fallowed, firstly to assist in controlling weeds, and secondly to assist in controlling such pests as Lucerne Flea and Red Mite. To do this it is essential that no weeds of any kind be permitted to grow. Where fallowing is not adopted it is necessary to plant the lucerne in drills, so that inter-cultivation may be carried out. Prior crops, such as oats, potatoes, etc., are advisable, as these crops assist in controlling weeds and loosening the ground. Where following a crop of potatoes, there is the added advantage of the residual fertiliser. Following on a cleaning crop the land should be worked down with harrows and disk cultivators. Before planting the seed, final preparation is necessary. This would consist of a further harrowing following up rolling to make a fine, firm seed-bed.

Time of Planting.

Lucerne can be seeded either in the autumn or in the spring, but the time of sowing will vary with a number of conditions. In warm and particularly the dry districts of Western Australia, autumn sowing, i.e., March or April, is likely to give the best results, provided the weeds and Red Mite can be controlled. Rain usually falls then and the ground is warm to ensure good germination of the seed, and a vigorous growth of the plants. During the winter, plants have opportunities to make good root growth, so that it becomes strong enough to stand the hot weather of summer. On the other hand, in cool districts with a liberal rainfall, or where weed growth, Red Mite and Lucerne Flea are troublesome, spring sowing is advisable. Where spring planting is practised, the ground should be fallowed in the autumn or winter, to assist in combating pests and weeds. If the areas are to be irrigated, the seed can be sown whenever convenient to the farmer. Generally the best results would be obtained from autumn planting.

Seed.

It is well known that a good seed-bed is essential for success, but the time and trouble expended on the preparation of it may be wasted by the use of poor seed, as good stands cannot be expected from such. Only seeds that are plump, bright yellow in colour with absence of hard dark brown, shrivelled or immature, and free from weeds should be used. Old seed is usually dull and darker in colour, as the brightness soon fades with age. In immature seed, it is generally greener in colour, even when not badly shrivelled. Germination tests of the seed prior to sowing are advisable, but still may not give a true index when sown into the soil.

Varieties.

There are several kinds of lucerne. These are, however, types rather than varieties, and are mainly of localised character and usually distinguished by the name of the country in which they have been grown, e.g., Peruvian, Turkestan, Arabian, African, etc. Many of these have been tried in Australia, including trials at the Chapman Research Station, W.A. The results obtained there are in accord with those obtained in the Eastern States, and are to the effect that none is as suitable for, or as prolific under Australian conditions, as the Australian type, which has been evolved as the result of the survival of the fittest. This early experience has been confirmed by experiments carried out by Dr. Dunne, the Merchants' Research Officer, Muresk Agricultural College. In the June issue of this Journal, 1935, he reported:—

"In 1932, a number of varieties of lucerne were collected and planted with a view to making preliminary comparisons of drought resistance and growth. The

following varieties of *Medicago sativa* were included, viz., Hunter River, Marlborough, Tamworth, Mudgee, Tagerim, South African, Provence, Italian, English, Chinese, Mongolian, Poitu, Spanish, Smooth Peruvian, Hairy Peruvian, Montana, Dakota, Kansas, Ladak, Utah, Hardigan, Arizona Common, California Common, North Californian and Grimm. Hardy lucerne, a variety of *Medicago media,* was also included.

"The experiment was carried out on a sandy loam soil which had been timbered with jam. The average rainfall at Muresk is 17 to 18 inches per annum, most of which falls during the winter season. The first reliable cropping rains usually occur about the beginning of May and the last useful rains during October. Occasional good falls are sometimes recorded earlier in the autumn.

"No supply of moisture was available for summer growth. The plants were not irrigated, and there was no subsoil seepage.

"It will be appreciated that, under these conditions, the most desirable varieties would be those which, in addition to being able to survive the dry summer months, were capable of making a reasonable amount of growth during the cooler months of the year. Varieties able to grow only under warm conditions would be unsatisfactory owing to the fact that during most of the warm weather no moisture would be available.

"Early rains were received in 1932 and planting was possible on 7th April. The rows were about half a chain in length and were spaced about 18 inches apart. Good germination was secured and all varieties made a satisfactory beginning. Superphosphate was applied at the time of seeding and thereafter each autumn and spring.

"It was found possible to cut the varieties three times each year, about the end of June and of September and during November. In a good season four cuts could be secured. Cutting was done when the most forward varieties contained a fair proportion of the plants in flower. At this stage the best varieties were 2 ft. 6in. to 3 ft. in height. The late September cutting was usually the best. The growth of the better varieties was considered very satisfactory for the conditions.

"The best two varieties as shown by the trial were North Californian and Hunter River. The former made a somewhat quicker recovery after cutting and made a little better growth during the colder months. However, the stems of this variety, which tended to become quite hard about the time of the November cutting, appeared to be normally rather coarse. This undesirable feature may possibly have been overcome by a heavier seeding. Hunter River made quite satisfactory growth throughout the season and had thinner stems and more leaf than North Californian.

"Hairy Peruvian, which made satisfactory growth, appeared to be the next best variety. In stem and leaf it was about intermediate between Hunter River and North Californian.

"There was little difference in value observed between a number of varieties comprising Marlborough, Mudgee, Tamworth, South African, Smooth Peruvian and California Common. All appeared to be inferior to those above mentioned.

"Practically no winter growth was made by varieties which have been selected for varying degrees of winter hardiness and ability to withstand extremely cold conditions. Any growth made was practically confined to October and November. These included the American varieties, Grimm, Ladak, Utah, Hardigan, Kansas, and Hardy, as well as Tagerim, Chinese, and Mongolian.

"All varieties under test were quite drought resistant and were able to keep alive over the dry summer.

"The preliminary trials indicate that, under conditions similar to those obtaining at Mursek, it is best to continue with Hunter River lucerne, which has already given satisfaction under a variety of conditions in Australia. More extensive trials may show additional merit in North Californian or Hairy Peruvian for these conditions, but until these are carried out no departure from the Hunter River variety can be recommended.

"Owing to the presence of other trials in the same area it was only possible to graze with sheep on one occasion (June, 1934). It is possible that the results may have been somewhat modified were the plants grazed instead of cut, but it is believed that in the main the conclusions would be similar."

At the Denmark Research Station similar results to those at Muresk were obtained, and in the drier districts it is now recommended that in addition to Hunter River lucerne, varieties known as North Californian and Hairy Peruvian can be sown.

During recent years advertisements have appeared in the agricultural press claiming very distinct advantages of certain strains of lucerne, the roots of which are offered for sale. These roots are said to be the progeny of a selected surface rooting plant, and it is claimed that planting them will result in the establishment of a superior type of lucerne. As the result of very careful inquiries growers cannot be advised to purchase these roots, as there is no evidence to show that they have any advantage over the best strains of the Australian variety. Observations in any field of lucerne will clearly reveal that many plants differ considerably in their vegetative characteristics, such as leafiness, rapidity of growth, drought resistance, and, in Western Australia, resistance to such pests as the Lucerne Flea (*Sminthuris viridis*) and Red Mite (*Halotydeus destructor*). Because of this, growers are advised to accept with caution the claim sometimes made for "new" varieties, especially those which are offered for distribution by roots.

Good seed of the right kind is essential, and therefore the grower should see that he obtains it by using Australian-grown seed, most of which now comes from New South Wales. Realising the superiority of seed produced in the Commonwealth, the Federal Government now insists that all imported seed shall be stained pink, so as to make it readily distinguishable from the local seed, which in colour ranges from green to purple. Most of the seed produced in the Commonwealth is grown in New South Wales in the Hunter River, Tamworth and Mudgee districts. Seedsmen are required to guarantee the germination and the maximum percentage of weed seeds and impurities in the samples offered. A good sample should have a germination of about 80 per cent., and should not contain by weight more than 1 per cent. of weed seeds and of impurities. The sale of lucerne containing dodder and other noxious weed seeds is absolutely prohibited.

Dodder.

Dodder (Cuscuta spp) is a parasitic plant vine which grows from seed. It is probably one of the most serious lucerne pests the grower has to face. The seed germinates in the soil and retains its connection with this until it comes into contact with the stem of the lucerne plant. It then severs its direct connection with the soil and lives upon the juices of its host, the lucerne plant, until it ripens its seed or has killed the host. Once started dodder continues to grow and spread by means of its tendrils, which grow from one plant and catch other adjacent ones. The plants first attacked begin to die and the pest spreads out in all directions.

Lucerne and Dodder.

The tiny seed of this pest is sometimes found in an admixture of lucerne seed, and because of this disastrous effect upon the crop, precautions should be taken to prevent its being introduced with the lucerne seed which is being sown. Because of the difference in their relative sizes, some dodder seed can be separated from lucerne seed by suitable cleaning machinery, but, because of the vital importance of not introducing dodder, only lucerne seed which has been harvested from crops known to be free from dodder should be used.

It may be, however, that despite the precautions taken, dodder has established itself. Every effort should be made to eradicate it. If very generally established, probably the best way of dealing with this pest will be to plough up the paddock and grow other crops upon it for a number of years until all the dodder seeds have germinated and the plants arising therefrom have been killed. For dealing with isolated patches the usual method recommended is to mow or hoe them, cover them with straw, and burn the dried material. Close and repeated grazing for some time may also prove effective, as the animals are likely to eat the dodder quite close to the ground and prevent it forming seed. Mowing has proved ineffective owing to the fact that little tendrils of the dodder plant are left on the lucerne stems near the ground and below the cut surface of the lucerne.

Rate of Seeding.

The amount of seed to sow per acre depends on the quality of the seed, the method of sowing, the nature of the soil, the firmness of the seed-bed, the district in which it is planted and for what purpose the crop is intended. Consequently, no general recommendation can be made. For hay-making purposes, the amount sown by farmers ranges from six to 20 lbs. per acre. If, however, it is intended that the crop shall be grazed, the quantity sown is much less and ranges from two to eight lbs. per acre. In some of the lucerne growing districts of the Eastern States where lucerne hay is the staple crop, the practice is to sow about 25 lbs. of seed per acre, and growers have been known to state that they would prefer to sow 30 rather than 20 lbs. per acre. This attitude is due to a realisation of the fact that many causes operate against plants succeeding and prevent more than a small percentage of the seed from producing healthy established plants; the young seedlings are tender and have difficulty in reaching the

surface after germination. During the process of covering many of the seeds sink too deeply into the soil, whilst many remain quite near or on the surface and fail owing to insufficiency of moisture. Further, whilst the lucerne crop is being established a process of elimination occurs, weeds rob the soil of the fertility, use up moisture, and compete with the lucerne for light. This makes the plants thin and spindly and generally saps their vigour, and in consequence it is only the strongest plants which survive.

It is considered that, when established, a stand of some 500,000 plants per acre is ample. Seeing that 1lb. of lucerne seed contains about 220,000 seeds the use of from 2 to 3 lbs. of good seed per acre would meet these requirements, and though it is recognised that a farmer should not run the risk of a thin crop as the result of being niggardly with the seed, it is considered that the use of 6 lbs. of good seed on well prepared land allows for the many contingencies referred to, and that to use more than 12 lbs. is unduly extravagant.

Generally speaking, in the South-West, if the seed is to be sown in drills, 6 to 8 lbs. per acre will be found satisfactory, but if broadcasted, 10 to 12 lbs. would be required for good results. Under irrigated conditions, 15 to 20 lbs. of seed per acre is recommended. In the wheatbelt a rate of 2 to 6 lbs. per acre should be used when sown in drills. All the rates of seeding mentioned for different conditions depend upon obtaining good seed and having good soil conditions before sowing, otherwise the rate of seeding per acre must be increased.

Method of Sowing.

Except on loose, drifting sands lucerne need not be sown with a nurse crop. There is a general agreement amongst experienced lucerne growers that if lucerne succeeds with a nurse crop it is in spite of the additional drain upon the soil moisture instead of by reason of it. This is particularly applicable to dry climates, for when there is only a limited supply of moisture available, all this will be required to germinate the seed and give the young plant a vigorous start in life.

The seed is usually broadcasted and should be sown near the surface. The seed may be broadcasted either by hand, by a hand broadcasting machine of the "Cahoon" or similar type, or through the grass seeding attachment of the ordinary grain and fertiliser drill. An even distribution of seed is desirable; it is not easy to obtain this by broadcasting with such small quantities of small seed. When necessary to sow by hand it is convenient to follow behind a roller or harrow, so as to have a clearly defined area on which to sow. The small quantity of seed used is dealt with by using the finger and thumb instead of the whole hand for picking up and spreading the seed; and sometimes to facilitate the work and ensure more even distribution the seed is mixed with dry soil, sawdust or ashes. When the hand machine is used a small quantity of seed can be sown best by turning the handle the opposite way to the usual one. The seed can be sown down the seed box of the grain and fertiliser drill if mixed with some bulky material like bran. It is sometimes mixed with superphosphate and sown through the fertiliser box, but this method is not recommended on account of the probable destructive action of the fertiliser on the vitality of the seed. When sowing the seed through the "shoes" of the grain drill there is some risk that the seed may be planted too deeply, but provided this risk is known it can be guarded against and avoided. When sown down the tubes of the grain drill the seed can be deposited on the surface by removing the tubes from the "shoes" and at the same time a broadcasting effect can be obtained by arranging for the seed to be dropped on to a sloping board fixed with an inclination of about 30 degrees to the ground.

The seed is sometimes sown in drills which are far enough apart to admit of intertillage. This method is believed to be the best for dry districts, and particularly for places where weeds are troublesome, and for small patches. It is further

recommended as the method to be adopted when determining the suitability of new locations for this crop. The results obtained by Mr. A.C.R. Loaring at "Lawnbrook," Bickley, with lucerne in drills 2 ft. 9in. apart, and recorded in the "Agricultural Journal," April, 1924, prove that there is no need to fear lessened yields from the adoption of this method, and it has several distinct advantages. It enables the land between the rows to be kept loose by cultivation, as the result of which loss of soil moisture by evaporation is reduced to a minimum, and the water is conserved for the use of the crop. Another advantage is that the cultivation given to conserve the moisture also destroys weeds, thus preventing the crop from being robbed of the plant food and moisture which the weeds would use for their growth. It has the further advantage that a saving of seed is effected when planting in this way, for, assuming that only 50 per cent. of the plants were obtained from the seed planted, 2 lbs. of seed will provide 15 plants per foot of row if the rows are 3 ft. apart. The seed is covered either by rolling or by harrowing with a light or brush harrow, but it is best covered by the joint operations of both rolling and harrowing. The rolling presses the seed into the soil, and in this way the germination is assisted; it is, however, undesirable to leave the surface compacted and smooth as left by the roller, for this tends to draw the moisture to the surface where it can be evaporated, and in addition a rolled surface crusts readily after a shower. These disadvantages can be overcome by lightly harrowing the rolled surface.

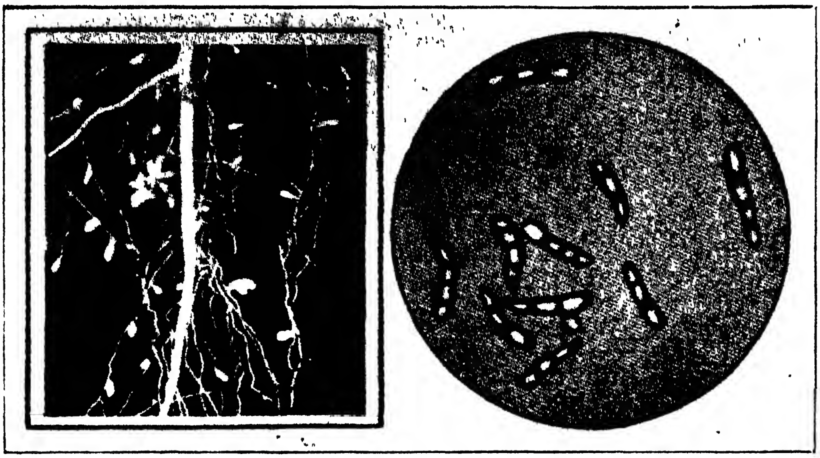
Innoculation.

Under certain conditions lucerne, in common with other legumes, is able to obtain the nitrogen for its requirements from the free nitrogen of the air, which contains about 80 per cent. It is enabled to do this by the aid of certain vegetable organisms or bacteria which derive their sustenance from the nitrogen of the air and the starch of the plant. When acting in this way the presence of these bacteria can be noticed by the appearance of wartlike nodules or tubercules on the roots. The nodular swellings are filled with the micro-organisms and are usually in clusters. Some are as small as a pin's head, others as large as a pea. It was thought at one time that each legume—lucerne, trefoil—had a distinct organism, but now it is believed that legumes of closely related kinds have the same organism and will pass from one kind to another. Thus the bacteria found on "White Sweet Clover" and on "Burr Medic" or "Burr Trefoil" have proved to be also suitable for lucerne, and similarly the one found on the Peas suitable for the broad bean or vetch.

These nitrogen collecting bacteria do not act when there is an abundance of nitrogen in the soil available for the use of the legumes. So to speak, they become lazy.

Seeing that in soils deficient in nitrogen lucerne will be dependent upon the presence of nitrogen-gathering bacteria for its supplies of nitrogen, it follows that if they are not present its development will suffer and will be shown by the pale colour of the foliage. It is important, therefore, to have these organisms in the soil; in fact, lucerne cannot be a complete success without them. Because of the manner in which trefoils flourish throughout this State there is every reason to believe that they will be present naturally throughout the agricultural areas wherever trefoils are found. If, however, they should prove to be absent, they can be introduced, and this process is called inoculation. In the past the most generally adopted method of carrying out the inoculation has been to distribute over the new land intended for lucerne a small quantity of the surface soil from an old established lucerne patch. Soil containing or infected with the required bacteria, at the rate of about

100 to 200 lbs. per acre, is harrowed in with the seed or just before sowing. The danger attendant upon this method is the risk of introducing weed seeds, fungus diseases, or eelworms.



Lucerne Nodules. Lucerne Bacteria

It was found that these nitrogen-fixing bacteria belonging to the different groups of legumes can be isolated and prepared for distribution in convenient form as "cultures." This scientific discovery was developed to such an extent that "cultures" for the different legumes were used with great success by mixing them with seed before sowing. Recently reports from England indicate that good results have followed the application of these "cultures" to old lucerne fields. In Western Australia excellent results have been, and are being, obtained from the use of "cultures" applied to new land at the time of sowing.

"Cultures" for lucerne and other legumes are now prepared in the laboratory of the Pathological Branch of the Department, and can be obtained by farmers on payment of a small charge.

The effect of lime is to encourage the growth of these bacteria. If the crop is not suffering from excess water, and there are evidences—such as the pale colour of the leaves, or the absence of the nodules on the roots—that the necessary bacteria are not functioning, mild lime at the rate of about one ton to the acre should be applied. On sour and sandy soils a similar dressing of mild lime is also recommended to be applied at least one month before the seed is sown. In addition to stimulating the bacterial activity already referred to, it will also have the effect of correcting the acidity which is so detrimental to success with lucerne.

Manuring.

Lucerne is a heavy feeder. Under suitable conditions twenty tons of green crop may reasonably be expected in a season, and this would contain about 340 lbs. of nitrogen, 60 lbs. phosphoric acid, and 250 lbs. potash. Fortunately, except during the period immediately following germination, this plant is not usually dependent upon the soil for its nitrogen supply. Being a legume it can, when suitable bacteria are present, obtain all its requirements in this connection from the inexhaustible supply contained in the air. But the phosphoric acid and potash must be obtained from that already in the soil or from fertilisers applied to the

soil. On fertile loams it may be assumed that the soil will contain sufficient nitrogen to meet the requirements of the young lucerne plant, and supply its needs until the necessary bacteria are sufficiently plentiful to enable it to secure all its needs in this connection from the air. Because the young plant requires to obtain its early nitrogen requirements from the soil, a small application of nitrogenous manure—sulphate of ammonia, blood, or nitrate of soda—is, however, recommended for sandy soils or others deficient in nitrogen-forming material. Guided by experience in the Eastern States, it is unlikely that, except in sandy soils, potash manuring will be necessary in the early stages, but it is equally likely that manuring with phosphoric acid will be followed by marked beneficial results. An application of from 2 to 3 cwt. of superphosphate per acre is recommended on all soils, even the best.

On loams poor in organic matter it will be advisable to supplement the superphosphate with an application of sulphate of ammonia up to 100 lbs. per acre, so as to meet the requirements of the plant for nitrogen until it is sufficiently established to obtain what it needs from the air. On such soils the fertiliser recommended is therefore:—superphosphate, 3 cwt. per acre; sulphate of ammonia, 1 cwt. per acre. The fertiliser recommended per acre for sandy soils or those deficient in plant food is a complete one consisting of, say:—sulphate of ammonia, 100 lbs.; superphosphate, 400 lbs.; muriate or sulphate of potash, 400 lbs.

Except in soils unusually rich it will be necessary to fertilise the crop annually. Subsequent applications of fertilisers should be governed largely by the returns aimed at or secured. If the soil is not rich enough for its latent fertility to be drawn upon, or if it is desired to replace the plant food removed by the crop, then an application of superphosphate 14 lbs., sulphate or muriate of potash 25 lbs., is recommended for every ton of green lucerne removed.

Well saved stable manure is very suitable for this crop, for in addition to the plant food it contains it also supplies organic matter to the soil, and this improves its mechanical condition. If kept on the surface it acts as a mulch to conserve the moisture, and will be of considerable assistance in preventing the formation of a crust on its surface. The great drawback is the weed seeds it contains for these, unless killed as the result of rotting, are likely to destroy the young lucerne plants. This objection is therefore lessened when the manure has been well rotted and is not serious when applied to well established lucerne beds.

Lime.

On sour and sandy soils a dressing of air slaked lime or ground limestone at the rate of 20 cwt. per acre is recommended as a preliminary dressing to be applied at least one month before the seed is sown. This will have the effect of correcting acidity and stimulating bacterial activity.

Treatment after Sowing.

Even in the best prepared soil, weeds are likely to spring up, for most soils, and particularly old and fertile ones, contain dormant weed seeds, and these germinate with the lucerne seeds and become a menace to its success. It is not possible to cultivate the ground to destroy the weeds which may grow amongst the recently-planted lucerne, for in its young state it is so delicate and with so little roothold that even a harrowing is likely to pull out or damage a considerable number of plants. Lucerne planted in the autumn will rarely be strong enough to be cultivated before the following spring, or that sown in spring before the following autumn. Short of hand-pulling, which is only possible on small areas, the most practical method of controlling weeds in young lucerne is to mow or

graze them. If this latter plan is followed the grazing should be done with small stock and as quickly as possible. The mowing can be commenced when the lucerne plants are four to five inches high, and repeated after a short interval, say, a month. This mowing, though detrimental to weed growth, will not injure the lucerne, but rather will stimulate it. Usually the material from the first mowing will not be worth gathering, and it can therefore be left, with advantage, to mulch the ground. As the object of this mowing is to destroy the weeds it should be undertaken whenever they are plentiful enough to warrant it, irrespective of the condition of the lucerne plants and the necessity for utilising the crop. It is emphasised that mowing does *not* injure but *stimulates* lucerne. When the young plants have a firm roothold, and this can be determined by pulling at them, cultivation of the soil can take place with advantage. Its effect will be to stimulate the crop by letting air into the soil for the benefit of the nitrogen-fixing bacteria, and by conserving the soil moisture. For the first cultivation a light harrow is probably the best implement to use, but as the lucerne gets older much stronger implements, such as the springtooth cultivator or disc harrow can be used. One of the best implements for the purpose on established lucerne—over two years old—is the disc harrow. To one not accustomed to its use it may be thought that it will destroy the lucerne as well as cultivate the soil. This, however, is not so. The discs should not be given too much angle, and they will then split the lucerne crowns and cause them to throw up additional stems.

When the soil of an established lucerne bed becomes hard it can be disced and cross-disced to loosen it up with most beneficial results. There need be no fear that surface cultivation will kill the plants, as they are too deeply rooted to be injured, and the splitting of the crowns is beneficial. Discing and cross-discing is extremely useful should the paddock unfortunately become infested with couch grass. On one occasion the writer had reason to deal with such a paddock, and so badly infested was it that the treatment decided upon was desperate and almost in the nature of a forlorn hope. The ten-acre paddock was double disced twice both ways. The result was astonishing. The lucerne grew with such astonishing vigour as to keep the couch under control when aided by the usual periodical cultivations with the disc, and because of the success which followed this drastic treatment, and which proved that couch grass and weeds could be controlled in established lucerne patches, additional acres of lucerne were planted on that farm.

Feeding Lucerne to Stock.

Lucerne as a food is particularly valuable for the protein it contains. Henry gives the average digestible nutrient in freshly cut lucerne and green fodder maize as:—

	Digestible nutrients per 100 lbs.		
	Protein.	Carbo-hydrates.	Fat.
Green fodder maize ..	1.0	11.6	0.4
Green lucerne	3.9	12.7	0.5

From this it will be seen that green lucerne contains nearly four times as much protein as green maize.

The nutrient protein is the most expensive of our food constituents and is essential for the production of lean meat, wool, milk, and eggs. Young animals, cows in milk, and laying hens require much protein, and because of the large amount of protein which it contains lucerne is very suitable for these animals. It can in many instances profitably take the place of bran or oilcake in the ration,

particularly of milking cows, and which farmers may have to purchase in order to utilise profitably and economically the other products of the farm, or to maintain a continuous milking period.

Comparative analyses of bran and lucerne hay, as given by Henry, are as hereunder:—

	Digestible nutrients per 100 lbs.		
	Protein.	Carbo-hydrates.	Fat.
Lucerne hay	11.0 ..	39.6 ..	1.2
Wheat bran	12.2 ..	39.2 ..	2.7

From the above the similarity between the two is obvious, and it is estimated that in practice 11 lbs. of good lucerne hay is equal to 10 lbs. of bran. In one respect lucerne has a very decided advantage over bran, and that is as a food for pigs. Lucerne is one of the best foods and bran one of the worst for these animals. In the United States of America large numbers of pigs are regularly pastured upon lucerne, and in this connection it is estimated that a vigorous patch of lucerne will carry 15 to 25 pigs per acre, and the pigs will make a gain of about 100 lbs. during the season. Whilst grazing lucerne with pigs it is best to supplement it with an allowance of grain, like maize or wheat. For fattening purposes lucerne will not be found economical if fed alone, for when fed alone all its protein cannot be digested and though the animals increase in weight such increase is principally of bone, blood, and muscle. For fattening animals lucerne requires to be supplemented with foods like maize, wheat, and oats, and other foods richer than lucerne in carbo-hydrates and fat.

Haymaking.

The object of transforming the green material into hay is to get rid of excessive moisture so that the hay when stacked will not heat too much or become mouldy.

Lucerne is much more difficult to make into hay than the cereals. This is because of the very sappy character of the stems, which do not dry as readily as the leaves. These latter are the most nutritious part of the plant, and if they become very dry are likely to fall off the stem during the operations of haymaking. The great object to be achieved therefore is to regulate the drying as far as possible so that the leaves and stems dry simultaneously. The principle underlying the procedure necessary for this is founded upon the fact that the leaves until they are so dry that they cease to function will transpire quite a lot of water and which they will draw from the sappy stems. The methods to be adopted should therefore aim to keep the leaves limp as long as possible, as whilst in this condition they will be drawing sap away from the stems very effectively. In practice the hay is made as far as possible in the windrows or in heaps or "cocks."

Lucerne may be cut at any time for green feed, and it may be accepted as an axiom that it is better at all times to cut early than late. Some farmers commence to cut the crop for hay shortly after the first flowers have appeared, others when the lower leaves begin to change colour. In some instances this latter may happen and the leaves begin to drop and the stems harden before the blooms appear. Unless the weather is very unsuitable for haymaking the mowing should not be delayed or loss may occur in three ways; in the first place the later cut or more mature material is less digestible. After flowering the food constituents are transferred to the upper portions of the plant, the stems harden and become less digestible than when younger; further some of the leaves wither and drop off and this results in loss in weight. Deferred cutting leads to poorer growth in the succeeding crop and may also result in a lessened number of cuttings during the season because of the greater time which the respective cuttings occupy the land.

The following table showing some results obtained at the Utah Experiment Station in a feeding test indicates the loss of nutriment following upon delay in cutting.

Stage of growth and beef lbs. produced per ton of hay-

When 1-10 in bloom—706 lbs.
When in full bloom—562 lbs.
When 1-2 of blooms have fallen—490 lbs.

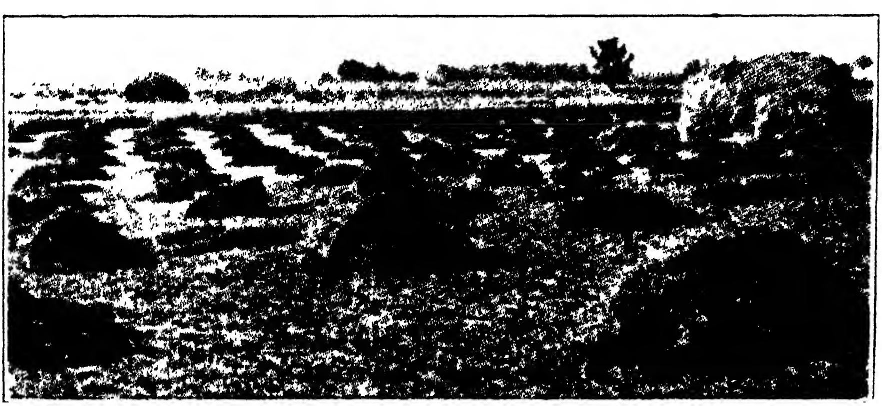
At the Kansas Experiment Station results obtained and the decline in the protein content consequent upon later cutting are as follow:—

Stage of growth and protein content—

When 1-10 in bloom—18.5 per cent. protein.
When 1-2 in bloom—17.2 per cent. protein.
When in full bloom—14.4 per cent. protein.

The first cutting for hay is ready early in spring, and except in the wheat areas, this crop will be difficult to make into hay on account of its sappy nature and the lack of much sun heat at this time. If this cutting can be used for feeding to stock in its green state it is advisable to use it in this way, or failing this, to conserve it as silage. The second and succeeding crops are much more easily converted into hay. In New South Wales when a crop of seed is required the third crop is usually utilised for this purpose, as the flowering at this period is usually more uniform than at others.

Lucerne is usually mown with a scythe, mowing machine, and on occasions with a reaper and binder; it should be cut as close to the ground as is possible without injuring the blade, so as to get the maximum amount of material and to force the new growth from the crown instead of from the joints of the old stems. The usual practice is to start when fine bright weather is expected and as early in the morning as is possible, but not until any dew which may have been deposited has evaporated. It is *not* desirable that the cut material be allowed to remain in the swathe too long, especially if the weather be hot, for extreme heat causes rapid drying of the leaves, and these are likely to fall off during the subsequent operations. If it is allowed to remain just long enough to wilt during bright fine warm weather, this will take only a few hours, whereas with cool moist conditions it may take as many days. After being wilted the material should be raked at once into windrows. If



Lucerne Hay.

the day is a bright sunny one and the mower has been started in the morning, the rake can be started at mid-day, and should catch the mower before night. The next morning the material in the windrows can be placed into heaps or "cocks," and if the weather remains favourable it is probable that the lucerne will be fit to stack the following morning.

Sometimes during hot weather the curing is completed entirely in the windrows, which should be made loose so as to admit the air freely, but in cool damp weather it will be advisable to place the material in "cocks" and allow the curing to finish in them. When dry enough or "cured," the hay is ready to be carted for stacking or baling. This is determined by an examination of the stalks, which need not be dry and brittle, but tough, though without any sap being noticeable when the stems are twisted tightly.

Just before carting, the "cocks" are sometimes turned over to expose the bottom hay for an hour or so to the sun, so as to dry off any hay that may be slightly damp owing to its proximity to the ground. Sometimes in very hot weather the hay becomes too brittle as the day advances, and there is a danger of losing the leaves, and the carting has to be confined to the mornings.

The time occupied from mowing to carting will vary with the season and according to the weather prevailing during the operations. Usually it is under three days, but may be as short as 24 hours. An extreme case was known by Dr. Sutton and is that of Mr. P. Reynolds, "Hobartville," Richmond, who on one occasion stacked his hay in the shed 16 hours after cutting.

Lucerne hay does not shed the rain well, and when stacked in the open should be thatched or protected in some other way from rain. It is best stored in sheds, and should not be stacked on the ground or on a raised straddle of earth; it requires a foundation or straddle of poles to admit air to the bottom of the stack. If stacked on the ground some is sure to spoil.

Grazing.

It is generally recognised that considerable damage can be done to a lucerne stand by indiscriminate grazing, consequently every care must be taken. W. J. Spafford, Deputy Director of Agriculture of the Department of Agriculture, South Australia, in an article on "Lucerne Growing in South Australia," stated:—

"Grazing the lucerne tends to shorten the life of the stand, because it is thinned out much quicker than if stock are never let on it, and if great care is not shown this killing of the plants will be brought about very rapidly.

"To get the best out of the crop without injuring it:—

(1) The crop should be well established before stock of any kind are grazed on it.

(2) The animals should be moved to another field, before they damage the stand.

(3) After resting the field, the plants should be allowed to make growth about a foot high before stock are again put on it.

(4) If possible, the crop should be fed down rapidly, and the stock moved on: this can only be done if the stand is divided into small fields."

Care should be taken when grazing stock on lucerne that they are not let in when it is wet, either by rain or dew, or when they are very hungry. Hoven is likely to be caused by feeding this succulent feed to hungry stock. The danger is greatly increased when the plants are wet. When cattle are being introduced

to this crop after a spell away from it, it is much better that they be well fed first so that they will not be able to consume great quantities, or, if this is not possible, to turn them on for thirty minutes and take them off, letting them on again for a similar period a few hours later. They soon become accustomed to the crop, and will be able to remain in the crop without danger. However, it must be said that grazing, whatever its advantages, materially lessens the life of a stand.

General.

Lucerne has many virtues. These have been summarised in most picturesque language by Geo. L. Clothier, of whom it is stated by Coburn in the "Book of Alfalfa" that he has studied his subject closely in the field, in the feed lot and the laboratory. His summing up is as follows.—

"The cultivation and feeding of alfalfa mark the highest development of our modern agriculture. Alfalfa is one of nature's choicest gifts to man. It is the preserver and the conserver of the homestead. It is peculiarly adapted to a country with a republican government, for it smiles alike on the rich and the poor. It does not fail from old age. It loves the sunshine, converting the sunbeams into gold coin in the pockets of the thrifty husbandman. It is the greatest mortgage lifter yet discovered.

"The alfalfa plant furnishes the protein to construct and repair the brains of statesmen. It builds up the muscles and bones of the war-horse, and gives his rider sinews of iron. Alfalfa makes the hens cackle and the turkeys gobble. It induces the pigs to squeal and grunt with satisfaction. It causes the contented cow to give pailsfull of creamy milk, and the Shorthorn and whitefaced steers to bawl for the feed rack. Alfalfa softens the disposition of the colt and hardens his bones and muscles. It fattens lambs as no other feed, and promotes a wool clip that is a veritable golden fleece. It compels skim-milk calves to make gains of two pounds per day. It helps the farmer to produce pork at a cent and half a pound and beef at two cents.

"Alfafa transforms the upland farm from a sometime waste of gullied clay banks into an undulating meadow fecund with plant food. It drills for water, working 365 days in the year without any recompense from man. The labour it performs in penetrating the subsoil is enormous. No other agricultural plant leaves the soil in such good physical condition as alfalfa. It prospects beneath the surface of the earth and brings her hidden treasure to the light of day. It takes the earth, air, moisture and sunshine, and transmutes them into nourishing feed stuffs and into tints of green and purple, and into nectar and sweet perfumes, alluring the busy bees to visits of reciprocity, whereon they caress the alfalfa blossoms, which, in their turn, pour out secretions of nectar fit for Jupiter to sip. It forms a partnership with the micro-organisms of the earth by which it is enabled to enrich the soil upon which it feeds. It brings gold into the farmer's purse by processes more mysterious than the alchemy of old. The farmer with a fifty-acre meadow of alfalfa will have steady, enjoyable employment from June to October, for as soon as he has finished gathering the hay at one end of the field it will be again ready for the mower at the other. The homes surrounded by fields of alfalfa have an aesthetic advantage unknown to those where the plant is not grown. The alfalfa meadow is clothed with purple and green, and exhales fragrant balmy odours throughout the growing season to be wafted by the breezes into the adjacent farmhouses."

Convenience in Pig Farming.

M. CULLITY, Agricultural Adviser.

The following notes are put forward with the hope that farmers will consider means of reducing the labour required in their pig feeding and management to a minimum. Haphazard methods in this avenue of farming frequently cause farmers to lose interest and to design their system of farming so that pig raising is reduced to the smallest possible scale.

The drudgery which is usually associated with pig feeding is unnecessary, and a little intelligent planning will reduce the time required, make the work more pleasant and allow the pigs to live in a condition more conducive to healthy growth and economical fattening.

Position of Piggery relative to the source of the basal food.

The first consideration that should have the farmer's attention is the relative position of the feeding troughs and the feeding base, that is the separator on a dairy farm and the grain supply on a wheat farm. In the dairying districts it is frequently the case in undulating country that the piggery is situated on higher land than the milking shed. This certainly has an advantage in that the pigs are on high ground and therefore drainage is adequate during the winter months. But undue labour is caused when the milking shed is on a lower level, as all the skim milk has to be carried uphill. This unnecessary labour causes the farmer to avoid this side of farming if at all possible, or at least to that point where pigs are kept solely as a means of using up the surplus skim milk. The pig is then regarded solely as a means of ridding the farm of that surplus rather than a very economical means of converting it into revenue.

In selecting a site for the pig runs, therefore, it is advisable to do so with a view to avoid unnecessary labour. When the piggery is on a lower level than the separator room there does not appear to be any reason why the milk should not be allowed to gravitate to a tank at the pens per medium of an open fluming or pipeline. Criticism may be made against these methods with reference to the possible corrosive action of the milk on the metal of the pipes and also to the difficulty of keeping them clean. Pipelines are in use on a number of farms, and appear to be giving satisfaction. Farmers report little difficulty in keeping these lines clean. The usual method is to flush them with cold water after the skim-milk has gone through and at regular intervals to follow this with hot caustic soda. This of course should then be rinsed from the pipes, preferably using boiling water. It appears to be unnecessary to give a caution against allowing the soda to reach the feeding tank. The provision of a tap at the lower end of the pipe is useful in allowing the pipe to be filled and allowed to soak. Where machine milking is being carried out, and the milk cannot be gravitated the use of a small pump will force the milk to the pens. This pump could be driven during separation and the added cost for this work would be infinitesimal, while the saving in time and labour would be incalculable.

In the case of a wheat farmer a similar saving would be effected if a supply of crushed grain were kept in a feed house as close to the feeding point as possible. This supply would need replenishing at intervals only.

Convenience in feeding may be achieved in those areas where grain is the principal part of the ration by utilising the self feeder. The pigs help themselves when hungry and periodic inspection only is necessary to ensure that ample food is available. (See J. of D.A., W.A., Vol. XIII., No. 4. Pigs—Breeding and Management.)

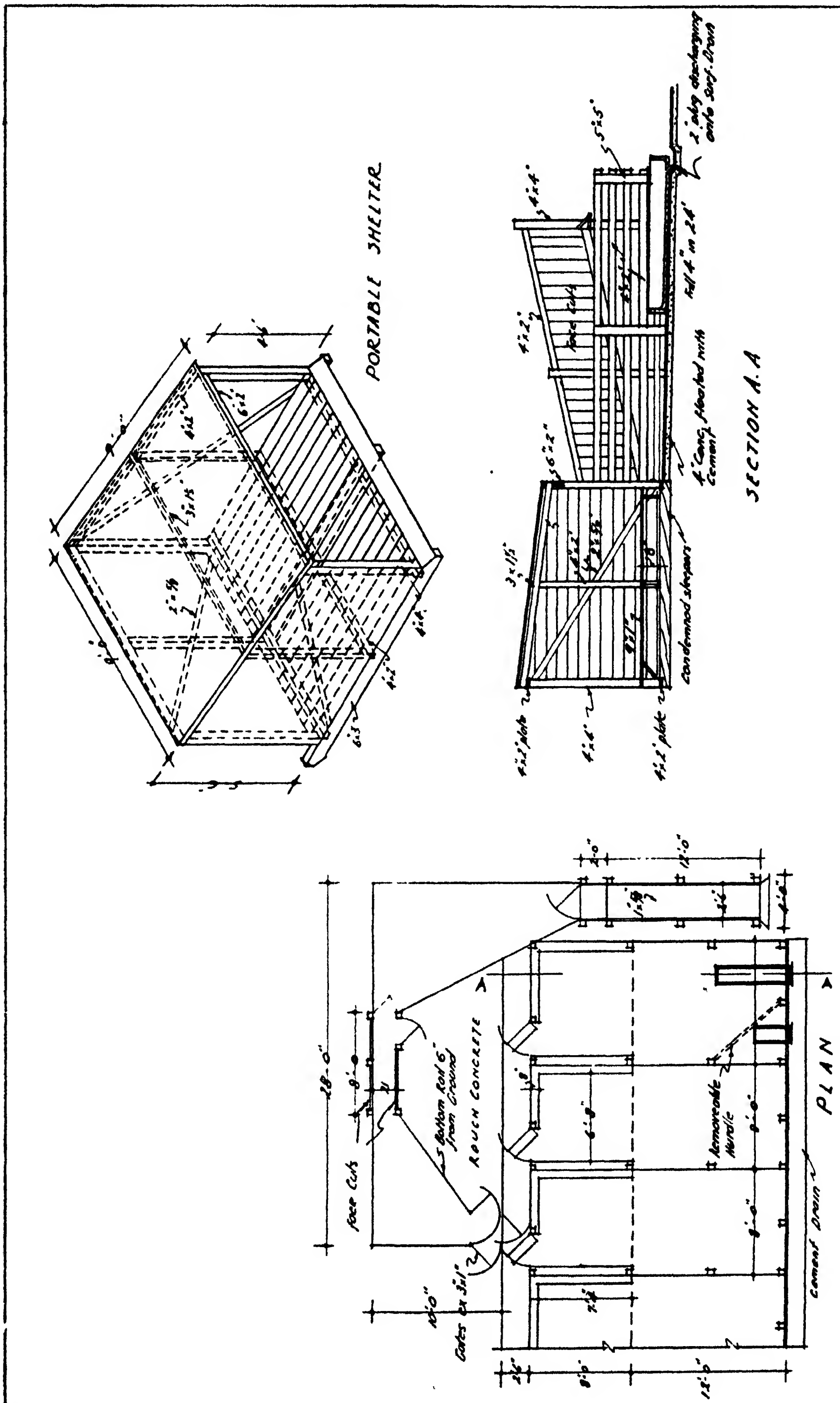


Fig. 1.—Layout of farrowing pens, the detail of the race and plan of the portable shelter.

Position of troughs and the method of feeding.

Having the food at the piggery the next consideration is how to get it into the troughs with the minimum of labour and annoyance and in the cleanest possible manner. A common practice is to have one or two feeding troughs in a sty. The feeder climbs over the fence with a bucket of milk and wages war on the hungry pigs until he can reach the trough and deposit the feed therein. This practice results in considerable splashing of milk, fouling of the man's boots and clothing, fraying of his temper and an undue physical strain.

In order to ensure the greatest possible degree of cleanliness there can be no doubt that no matter what the design of the piggery, the feeding trough should be on a concrete base.

For convenience the trough should be near the fence to facilitate feeding without creating the necessity for the feeder to enter the sty. This can be effected

Fig 2
A concrete feeding ra e with troughs projecting from the sties (Photo Miss D. Noon)

by having the trough at right angles to the line of fence projecting sufficiently through to enable the milk to be poured in. (See Figs. 1 and 2.) The milk then flows along the trough inside the fence. A disadvantage of this method is that it usually causes a struggle amongst the pigs for the position nearest the fence, when the rapid drinker will obtain more milk.

When the trough is placed along the fence line a swinging hurdle (Fig. 3.) may be used to shut the pigs away from the trough until the feed is placed therein. The hurdle is then returned to its normal position and the pigs allowed to feed. This method is useful when feeding either liquid or dry feeds. Another method entails the provision of a metal chute via which the milk can be poured from the outside of the fence.

The possibility of eliminating the carriage of milk from the holding tank at the sties to the troughs by installing a readily dissembled pipeline with cocks over the troughs is being considered by a few farmers.

Whatever system of feeding is adopted, strong advocacy is made of those methods which do not require the feeder to enter the sty. Apart from the circumstances mentioned earlier, it is almost certain that the flesh of those pigs nearing marketing weights will be blemished through the scramble for the bucket and by the man forcing his way through them to the trough.

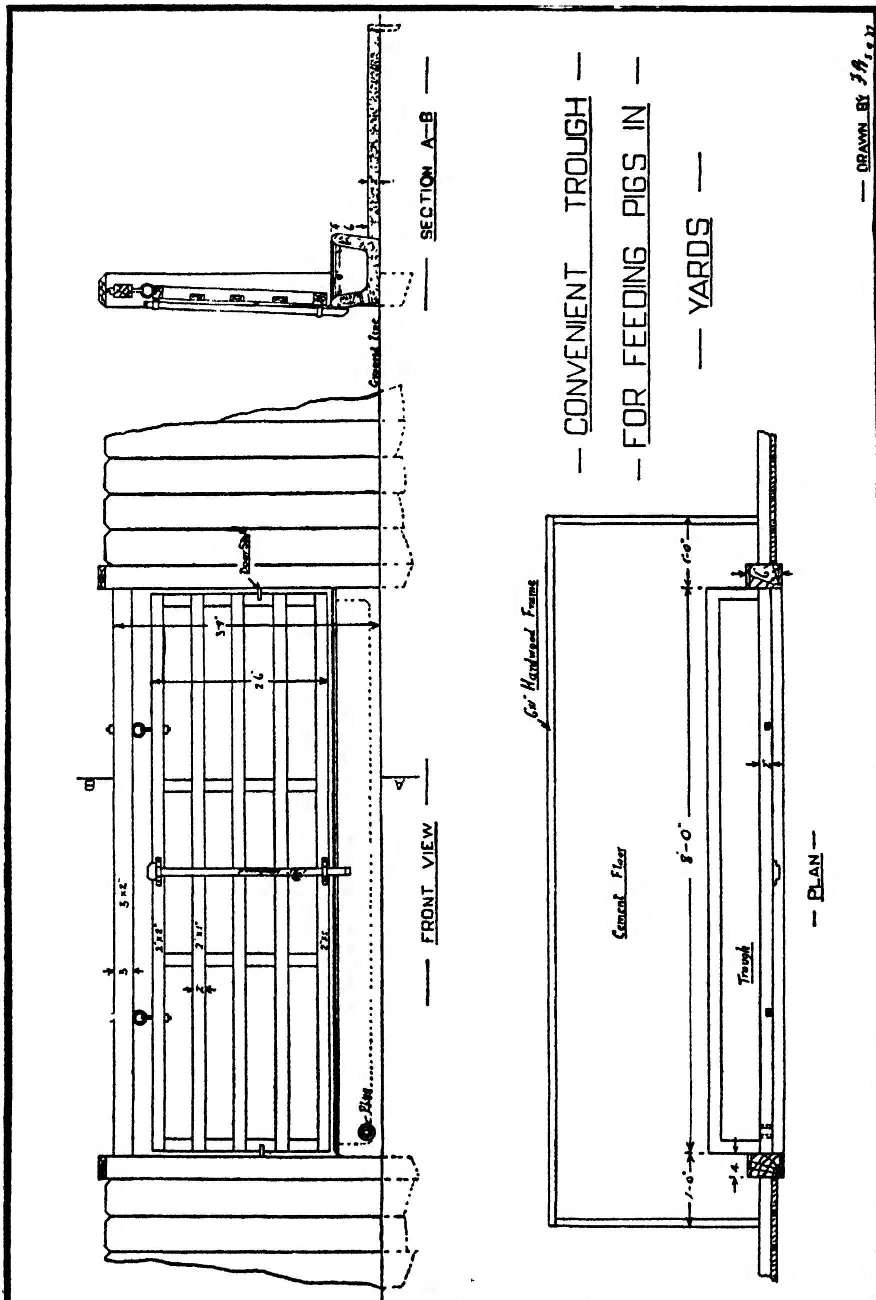


Fig. 3.—Plan of feeding trough showing the swinging hurdle.

Sufficient trough room must be allowed to hold all the food to be given, and it is also necessary that sufficient room be available for all the pigs to feed at once. As a guide it may be suggested that at least one foot length of trough be allowed for each pig. Slats at this distance apart are frequently used to prevent burly animals from forcing weaker ones away. They also have the effect of preventing pigs from getting into and lying in the trough.

Grouping of pigs according to weight.

There are several disadvantages in running too many pigs together. For convenience and at the same time to enable feeding to be carried out according to the stage of growth of the pig, a number of pens and paddocks should be provided. This enables the farmer to segregate his pigs into relatively small groups according to their weights. Where this is not done certain of the stronger pigs will consume more than their proportion of the feed to the detriment of the weaker.* Having the additional accommodation ensures that struggling and fighting among the pigs will be reduced to the smallest possible extent, and gives each pig a reasonable chance of growing under calm conditions.

Creep feeding of litters.

In the case of sows and litters, it is the exception rather than the rule to feed the litter separately from the mother. After about three weeks the young pigs are willing to forage a little for themselves and attempt to feed at the mother's trough. The amount they can consume in competition with her is small, and they incur the additional risk of injury through being nosed out of the way. The provision of a creep is one of the surest methods of rearing a weaner which will be an economical fattener later. The operation of the Manuwatu-Ororu Pig Recording Club in New Zealand demonstrated that creep feeding was responsible for the production of the strongest pigs and these carried their rapidity of growth into their later development. McMeekan and Hammond have since demonstrated that it is advisable to feed the pig during the early months so that it will make its most rapid growth. For bacon pigs they suggest that approximately the first two-thirds of the feeding period should be full fed and that it is then most profitable to reduce the rate of feeding so that the animal will develop to bacon weights without laying on undue fat.†

Cleanliness.

The condition in which the piggery is kept has a very decided effect on the farmer's reaction to the job of pig farming. The degree of cleanliness is frequently bound up with the design of the premises. If this design or layout is good and the floors and pens at least can be kept clean of the mess that is frequently seen, the farmer will not react so quickly to a fall in price, by quitting his breeding animals and letting this sideline lapse. Should the conditions be the reverse, a fall in price is often a heaven-sent excuse to reduce the scope of the operations.

Farrowing Pens.

In Fig. 1 is shown a suggested layout for six farrowing pens which may also be used as fattening pens. Larger feeding pens and paddocks also can be provided. A race system has been designed to facilitate the handling of animals to and from the paddocks to the pens or loading ramp.

* A simple creep is described in the article on Pigs, Breeding and Management by G. K. Baron-Hay, J. D.A., W.A. Vol. XIII, No. 4, and its position in the pen is indicated in Fig. 1.

† It is during this early period that the pigs make their bone and muscle and the continuation of this full feeding as they approach maturity will only lead to surplus fat.

Pasture.

Pasture is strongly advocated as a means of providing part of the ration, the necessary vitamins which can be obtained most cheaply from green material, and also serves as the opportunity of giving the animals exercise. But the means of providing this pasture is often thought to be simply the provision of a small paddock in which there is very soon no pasture. The writer can see no objection to allowing the pigs to run over the dairy pasture as long as precautions are taken to prevent any tendency of the pigs to harm the pasture by rooting. In some close settled localities this is not possible owing to the tendency of pigs to roam, unless pig-proof boundary fences are present. Nose rings are most commonly used for the purpose of preventing rooting, and are quite effective while they remain. But owing to these breaking away, replacement is often necessary. Snout clipping is permanent and removes any tendency of the animal to root, as portion of the cartilaginous matter in the snout is removed and the animal is no longer capable of forcing the snout into the ground.

Improved Berkshire pigs on Kikuyu grass pasture. Good mesh fences are noticeable. (Photo Miss D. Noon.)

Where the use of the dairy pastures is not convenient, the small paddock system is recommended. The number of paddocks that will be required will depend on the number of pigs that one plans to feed. These paddocks will tend to get bare, so provision must be made for resting or cultivating them periodically. For this reason it is advisable to have a number of paddocks which, because they are small, should preferably be long and narrow. This has the double advantage of easy cultivation and the possibility of using temporary cross fences to segregate the pigs on to set portions. These paddocks should be connected to the fattening pens and loading ramp by a laneway.

In Fig. 5 is a layout of paddocks which is adaptable to most conditions other than on very hilly country. This system allows cultivation and rotational grazing, so giving the maximum of food material, and tending at the same time to keep the animals in health by giving them ample exercise.

A diagram of a movable shelter for use in such paddocks is given in Fig. 1.

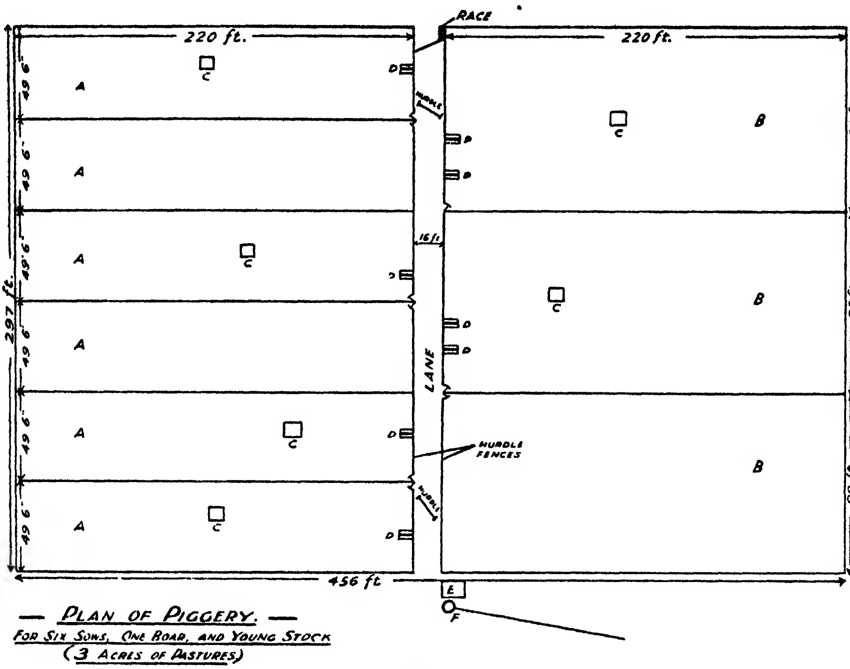


Fig. 5
Plan of paddo k system.
(With acknowledgments to the Queensland Agricultural Journal, March, 1934.)

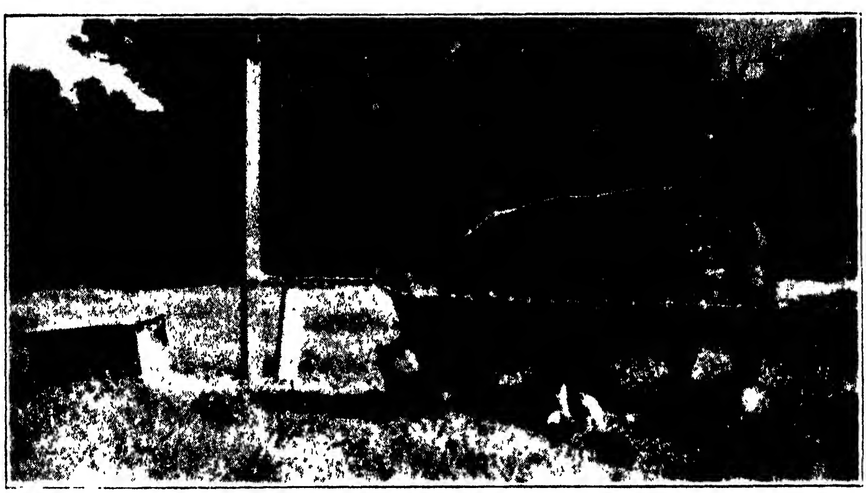


Fig. 6.
Electric fencing is useful for temporary fences. Note the difference in the pasture inside and outside the fence.

Loading for Market.

The time eventually arrives when pigs have to be marketed, and this again can cause considerable bother and damage to the pigs through the manner in which they have to be handled.

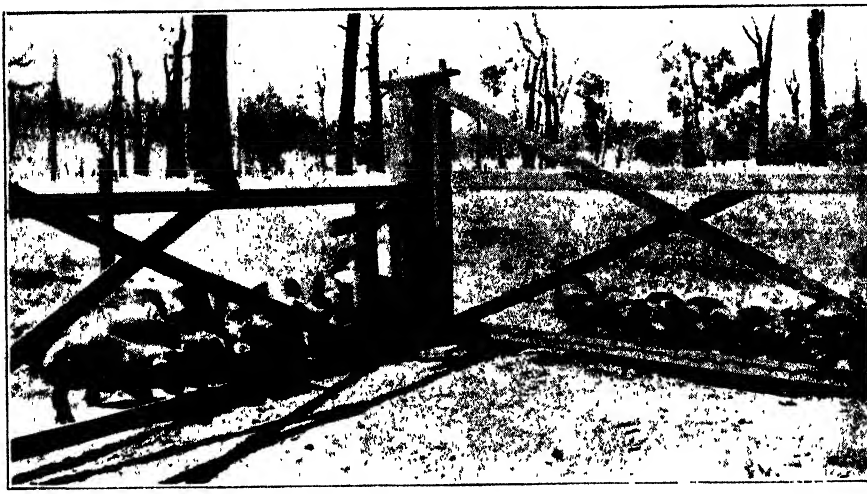


Fig. 7.
Young pigs waiting to go back to their pens from Kikuyu grass paddocks. Note the effective gates
(Photo Miss D Noon.)

Each piggery should be equipped with a small drafting yard and loading ramp. This will permit the loading of pigs with the maximum of ease. It will be noted that a drafting yard is included in the design in Fig. 1.

In handling the marketable pigs through this yard, very great care should be exercised so that the flesh is not bruised. The use of sticks for prodding, kicking, and the use of dogs, should all be decisively discountenanced, as each is the cause of blemishes which cannot be removed. In manhandling any pig, it is suggested that the same care be used. Frequently one sees a pig being dragged along by one hind leg. This can only result in the straining of some muscle with consequent loss.

Some Soil Types Associated with Manganese Deficiency of Cereals in Western Australia.

By

L. J. H. TEAKLE and A. S. WILD.

Introduction.

Since the recognition by Carne (1927) of "Grey Speck" disease or "White Wilt" of wheat and oats, a condition associated with deficiency of available manganese in the soil, observations have shown this disorder to be of common occurrence, but affecting only limited areas, throughout the wetter portions of the wheat belt south of the main East-West railway line. As described by Wild (1934) the symptoms generally occur in small patches usually a few square yards in area, but seldom more than a few acres in extent, in crops of wheat or oats

grown on high level soils. The disease is most commonly associated with soil types which, in the virgin state, carried mallet (*Eucalyptus astringens*), Manna gum (*Acacia microbotrya*), morrel (*Eucalyptus longicornis*) and mallees (*Eucalyptus spp.*). These soils exhibit characteristic features; they are very rich in ferruginous gravel (laterite), especially in the subsurface layers; the surface sandy layer is of a loose, ashy, or powdery structure; they are slightly acidic in reaction and of low inherent fertility.

On these soils wheat and oats show the characteristic manganese deficiency symptoms. As described by Carne (1927), the symptoms first appear in June or July as stunted yellowish or whitish patches in the crop. Examination of the individual plants shows that while the first and second leaves are generally normal, later leaves characteristically show a spotting somewhere about the centre. These spots are generally light coloured with a pinkish tinge, but later develop grey centres. Usually the spots spread until they cross the leaf, forming an irregular, dead, grey band, while both ends of the leaves are still green. Collapse occurs at the dead area and the upper part of the leaf hangs down, giving the plant a drooping appearance. Subsequently, the balance of the leaf turns yellow and then greyish white as it dies. In addition, the rooting system appears to be defective as the plants are very easily pulled from the soil. If plants survive the winter they frequently recover with the warmer weather of August and September but in cases of acute deficiency the bulk of the plants usually die and the affected area carries only scattered survivors.

Adams (1937) has described the incidence of manganese deficiency of wheat and oats in the Northam district on ferruginous, gravelly soils which originally carried a woodland of wandoo (*Eucalyptus redunca* var. *elata*) and observes that field peas and subterranean clover are less susceptible to the disease. Stewart and Teakle (1939) noted improvement in growth of wheat on patches of ferruginous, gravelly soil at Wagin where manganese sulphate was applied with superphosphate. Similar symptoms are commonly observed in patches in oat crops in the wetter South-Western districts.

However, Teakle, Thomas and Hoare (1933) have shown that the wheat belt and South-Western soils generally show no response to manganese dressings, so that acute manganese deficiency appears to be restricted to certain soil types of relatively limited extent.

Soil Survey of a Farm affected by acute Manganese Deficiency.

a. *Cropping History.*

In the course of advisory work by one of us (A.S.W.) in the wheat districts east of Wagin, a visit was paid early in 1938 to a property which had been cleared and cropped over a period of about 25 years and on which there had been many partial or complete crop failures. Field tests involving the use of manganese sulphate and conducted over a period of two years proved the value of this amendment; satisfactory crops could be produced on the affected soil types when manganese sulphate, at the rate of about 14 lbs. per acre, was applied mixed with the superphosphate. Figure 1 shows the effect in 1939 of withholding manganese on the growth of wheat on manganese deficient soil types on this farm. In this instance the soil type concerned is the Tinkurrin gravelly sand which is described below. Without manganese, the wheat germinated normally and grew satisfactorily for a few weeks. As the season progressed, however, the plants began to look drooping and unthrifty, exhibiting the usual symptoms of man-

ganese deficiency and, in the course of time, a large proportion died. Scattered plants produced heads but grain formation was typically scanty. Where manganese had been applied the crop grew normally and produced a satisfactory yield of grain for the soil type involved—about 15 bushels of wheat per acre. Observations in 1938 indicated that the application of sulphate of ammonia would prevent the development of symptoms of "Grey Speck" disease in wheat on the same soil type on this property. It had previously been shown by Carne (1927) that sulphate of ammonia is beneficial under these conditions, but it is not considered that the effect of this treatment indicates that the disease is not due to a deficiency of available manganese.

Figure 1.—Photo taken on September 14th, 1939, of a strip showing the failure of wheat to make satisfactory growth where manganese sulphate had not been used on the Tinkurrin gravelly sand. As the season advanced the bulk of the surviving wheat plants died on the strip without manganese.

As this farm involves such an area of manganese deficient country, it was thought that it afforded an opportunity for examination of the relationship between the manganese deficient soil types and other soils of the area. Consequently, a soil survey was made in January, 1940, and it is the purpose of this paper to record the observations made.

b. *The Soils and Parent Materials.*

The farm examined covers 1,000 acres of undulating country ranging from high level mallee and scrub plain types to normal salmon gum and morrel soils along the creeks. A clearer understanding of the relationships of the soils can be obtained if the area is regarded as portion of an eroded plateau. The plateau is capped by an horizon of sand and laterite (ferruginous gravels and quartz

gravels coated with ferruginous materials) but where erosion has occurred in the course of the dissection of the plateau, this capping has been removed, or broken up and redistributed. Where removal has been complete the country rock of granite or gneiss is exposed. The upper portion of the country rock exposed by the removal of the laterite capping appears to be a highly kaolinised horizon of weathering. This is often characterised by a considerable amount of quartz grit.

Where the gravelly and sandy materials remain, the soils are poor in fertility and usually carry either a scrub or mallee type of vegetation. These soils may be sandy or gravelly and certain types exhibit acute manganese deficiency of cereals. The Tinkurrin gravelly sand is a good example of one of these types.

Where the gravelly materials have been removed the soils generally range in colour from light grey to grey brown and exhibit the typical features of the grey and brown solonised soils of the so-called "mallee" zone (Teakle 1938).

Mineralogical examination kindly carried out by Dr. Dorothy Carroll of the University of Western Australia, indicates that each soil series is derived from slightly different types of gneiss. The presence of hornblende in Type 1A suggests that it is derived from a hornblende gneiss. The Kukerin sandy loam and Tinkurrin gravelly sand types appear to have been derived from gneisses which contain very little hornblende. In all types the clay minerals of the subsoils appear to be of the kaolinite group. The heavy mineral assemblage is indicated by the following data showing the approximate proportion* of the chief constituents and the relative abundance of other minerals of the heavy residue.

Sample No. ... ... Series	3090 1A	3111 Kukerin	3069 Tinkurrin	3082 Tinkurrin
Heavy mineral—				
magnetite	60–70%	25–50%	25–50%	25–50%
ilmenite	up to 25%	up to 25%	up to 25%	up to 25%
zircon	up to 25%	up to 25%	up to 25%	up to 25%
leucoxene	plentiful	plentiful	plentiful	plentiful
amphibole	plentiful	scarce	scarce	scarce
rutile	scarce	fair	fair	scarce
tourmalin	scarce	*nil*	scarce	scarce
garnet	fair	scarce	*nil*	fair
sphene	*nil*	fair	fair	fair
corundum	*nil*	*nil*	scarce	*nil*
epidote	fair	*nil*	*nil*	scarce
monazite	scarce	*nil*	*nil*	*nil*
sillimanite	scarce	*nil*	scarce	*nil*

* The percentages indicate the range observed for the one sample in different fields under the microscope.

In the course of the soil survey seven groups of soils were recognised on the basis of soil profile features. These groups have been subdivided into a number of soil types which will be described below. Figure 2 shows the distribution of the main soil groups on the farm surveyed.

Group 1—245 acres.

Salmon gum (***Eucalyptus salmonophloia***), morrel, York gum (***Eucalyptus foecunda*** var. ***loxophleba***) and mallee vegetation associations on soils typical of the mallee zone and largely confined to the lower portions of the area where the parent material appears to be hornblende gneiss.

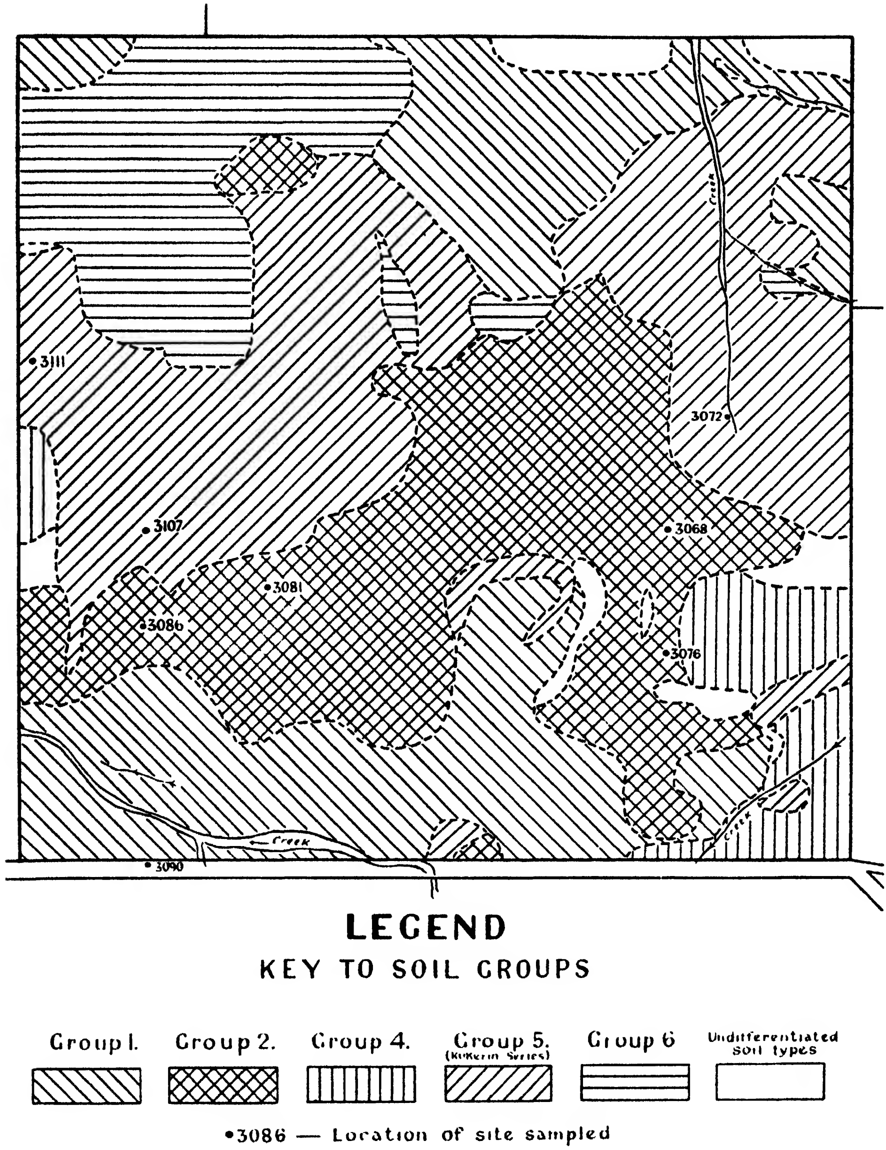


Figure 2.—Sketch map showing the occurrence of the main soil groups recognised in the course of the soil survey. The cross hatched area represents Group 2 which is generally deficient in available manganese.

Type 1A.

The typical features of the profile of this type are given in Table 1.

At the site sampled the vegetation included salmon gum, centipede bush (*Templetonia sulcata*), forest daisy (*Olearia Muelleri*), needle bush (*Daviesia aphylla*), *Acacia erinacea,* broom bush (*Melaleuca uncinata*), *Danthonia, Grevillea* and *Restionaceae.*

TABLE 1.

PROPERTIES OF A SOIL REPRESENTING TYPE 1A.

This site represents virgin conditions.

Serial No.	Depth.	Gravel.*	pH.‡	Salt (NaCl).	Description.
	inches.	%		%	
3090	0—3	2·6	5·9	·03	brownish grey loamy sand.
3091	3—10	*Nil*	7·9	·07	cementy layer to yellow brown sandy clay.
3092	10—18	12·7†	8·6	·16	yellow brown sandy clay with calcareous nodules.

* Per cent. of the fine earth plus gravel. † Largely calcareous nodular material.
‡ pH of 1 : 5 soil : water suspension by quinhydrone method.

Type 1B.

This soil is similar to type 1A but the profile shows 6-12 inches of sand on the surface and a subsoil slightly lighter in texture. Lime accumulation occurs at greater depths.

Type 1C.

Brown to greyish brown gravelly sandy soil with a brown sandy clay subsoil. The surface sand is less than six inches deep. Patches of red brown gravelly soils may occur in this type.

Type 1D.

Type 1D is similar to type 1C but has a surface of 6-12 inches of gravelly sand.

From the cropping point of view the soils of Group 1 have been the main producers of wheat and oats since the land on this farm was first worked in 1913.

Group 2—251 acres.

Soils of the upper sandy and gravelly horizon which show more or less acute manganese deficiency.

The surface soil in these types is sand, usually more or less gravelly, and is typically of an ashy, or powdery structure immediately below the surface. The subsurface generally consists of loose gravelly matter mixed with loose sand, and the subsoil is a sandy clay. While the surface sandy and gravelly layers are typically slightly acid in reaction, the subsoil, where clay accumulation is noticed, is generally alkaline. In some instances small amounts of calcium carbonate occur in the subsoil. The occurrence of calcium carbonate in the subsoils of typical soils on lateritic material is very unusual. In this case it is possible that it may be due to the thinness of the gravelly horizon and the nature of the parent materials. On the other hand, this soil type is known to carry mallees in the virgin condition so that the calcium carbonate accumulation may be due to the effect of a mallee vegetation association growing on these particular sites. The writers know of no instances of such calcium carbonate accumulation under heath associations, but it is well recognised that soils carrying mallee characteristically show accumulation of calcium carbonate in the subsoil. Unfortunately this farm had been cleared and cultivated for many years and evidence of the original vegetation on these sites was not obtainable.

This group has been divided into four types of which one, covering the largest area, and typical of manganese deficient areas in many other places, has been given a series name and is called the Tinkurrin gravelly sand. The other soil types of the group are similar generally, but exhibit differences sufficient to warrant their recognition as separate soil types.

The vegetation of this group in the virgin state includes mallees (*Eucalyptus dumosa* and spp.), morrel, mallet (*E. astringens*), manna gum, *Hakea* spp., etc.

The Tinkurrin* gravelly sand.

Details of typical profiles of the Tinkurrin gravelly sand are given in Table 2 and need not be repeated in the text. It will be noticed that this type is characterised by a very heavy concentration of ferruginous gravel and that the surface soils are slightly acidic in reaction.

Type 2A.

The profile of this type consists of a light brown sharp, coarse sand with loose gravel, resting on a yellowish gritty sandy clay loam subsoil. In the virgin state the timber consists of morrel and manna gum. This type is probably transitional between the Tinkurrin gravelly sand and Type 1A or 1B.

Type 2C.

A brown soil type which is evidently very deficient in available manganese. The profile consists of about 5 inches of grey brown powdery gravelly sand on a dark fawnish brown very gravelly sand to a depth of 12 inches. Below this is a layer of brown to yellow brown sandy clay loam extending to 2 feet and resting upon a red and yellow mottled clay with pockets of ferruginous gravel. Further details concerning this type are given in Table 2.

TABLE 2.

PROPERTIES OF SOILS REPRESENTING GROUP 2.

(*Manganese deficient types under cultivation.*)

The gravels consist of ferruginous nodules or quartz coated with ferruginous material.

Serial No.	Depth.	Gravel.*	pH.	Salt (NaCl).	Description.
Tinkurrin gravelly sand—					
	inches.	%		%	
3068	0—4	22·2	6·4	Trace	brownish grey ashy, powdery gravelly sand.
3069	4—18	70·8	6·3	Trace	greyish yellow very gravelly sand—very loose.
3070	18—36	50·3	6·5	Trace	yellow, yellow brown and reddish mottled very gravelly sandy loam.
3071	36—42	56·0	6·7	Trace	similar but a sandy clay loam.
3081	0—3	14·9	6·3	Trace	brownish grey gravelly, powdery sand.
3082	3—13	51·5	6·5	Trace	pale yellow grey sharp, loose sand and loose round gravel.
3083	13—20	11·3	8·2	·01	similar but a sandy clay loam.
3084†	20—35	10·1	8·4	·02	dark yellow sandy clay loam.
3085†	35—42	12·5	8·3	·02	yellow and grey mottled sandy clay, reddish at 40 inches.

* Well defined soil types have been given series names as a means of more definite characterisation; these names have been taken from the districts in which the types are known to occur.

TABLE 2—*continued.*

PROPERTIES OF SOILS REPRESENTING GROUP 2—*continued.*

(*Manganese deficient types under cultivation.*)

The gravels consist of ferruginous nodules of quartz coated with ferruginous material.

Serial No.	Depth.	Gravel.*	pH.	Salt (NaCl).	Description.
Type 2C—					
3086	0—5	15·7	7·1	Trace	grey brown gravelly sand slightly powdery.
3087	5—13	47·0	7·3	Trace	brown to dark fawnish very gravelly sand.
3088†	13—23	24·2	8·3	·02	brown to yellow brown gravelly sandy clay loam.
3089†	23—29	20·1	8·2	·02	red and yellow gravelly clay.
Type 2D—					
3076	0—4	22·4	6·5	Trace	grey coarse gravelly sand.
3077	4—16	67·8	6·6	Trace	loose rounded gravel and whitish sharp sand.
3078	16—26	64·1	7·0	Trace	grey yellow sandy loam and gravel.
3079	26—36	34·9	7·4	·01	yellow and grey mottled gravelly clay.
3080	36—42	11·8	7·3	·02	C horizon of yellow grey and red gritty, talcy, clay.

* Per cent. of the fine earth plus gravel. † Small amount of calcium carbonate present.

Type 2D.

Type 2D is another transitional type, rather greyer in colour than the others of this group, and appears to be intermediate between the Tinkurrin gravelly sand and representatives of the Kukerin series described below. Details of the profile are given in Table 2 and show that the type resembles other members of this group in being extremely gravelly. It is possible that this type is also deficient in available manganese.

The cropping history of the soils of Group 2 has been one of failure or partial failure of cereals. Either under fallow or wet ploughed conditions, the results have been much the same. The crop has looked poor during the early part of the growing season and has progressively died off during subsequent months so that the returns have practically amounted to a complete failure. During the 1939 season the Tinkurrin gravelly sand in one paddock was treated with a mixture of manganese sulphate and superphosphate as fertiliser, with the exception of a strip which received superphosphate only. The crop was a success, except on the strip without manganese, where it proved a complete failure as a large proportion of the plants died before reaching maturity. The appearance of the strip without manganese in early September is shown in Figure 1. By harvest time very little growth of wheat occurred on the affected strip.

Group 3—12 acres.

Patches of very gravelly soils which have not been differentiated.

Group 4—52 acres.

Sandy surfaced soil types which carry a mallee vegetation association and belong to soils characteristic of the mallee zone. The general profile features are a surface of 5-12 inches of grey to grey brown coarse or gritty sand with a cementy subsoil of yellow brown to olive grey gritty sandy clay; red mottlings show with depth, especially where waterlogging occurs. Some types show ferruginous gravel in the profile. Soil types of this group were not differentiated in the mapping.

Group 5—295 acres.

A series of mallee soils, apparently derived from gneiss, and characterised by an abundance of quartz grit, especially at the surface, a light grey surface

colour and calcium carbonate accumulation in a cementy subsoil of highly alkaline reaction. When mixed with distilled water the clay of the subsoil is slow to disperse but yields a very stable milky white suspension.

Two types within this series have been recognised on the basis of the depth of the surface sand.

The Kukerin sandy loam.

The profile of this type consists of a few inches of grey gritty sand on a cementy, grey yellow to yellow brown gritty sandy clay. Calcareous rubble occurs in the subsoil. It is described as a sandy loam as the shallow sandy surface is buried and mixed with the subsoil clay in the course of cultivation. During the summer months areas of this type are characteristically cracked on the surface, due to the contraction of the clay on drying out. In the virgin state this type carries a thick growth of stunted mallees (*Eucalyptus eremophila* and spp.), and appears to be related to the moort (*Eucalyptus platypus*) country further south. Portions of this type show salt patches, and, where salt appears, further damage has been caused as a result of the removal of the surface soil by wind action.

Table 3 gives details concerning representative profiles of the Kukerin sandy loam.

The Kukerin sand.

The Kukerin sand is similar to the Kukerin sandy loam but is characterised by a deeper layer of sand on the surface. A typical profile consists of 4-6 inches of grey loamy sand on a cementy subsoil of greyish yellow sandy clay; a certain amount of ferruginous gravel may be present. Below a depth of about 18 inches the clay is somewhat similar in nature but contains dense, hard, calcareous nodules. The properties of a representative profile of the Kukerin sand are given in Table 3.

TABLE 3.
PROPERTIES OF SOILS OF THE KUKERIN SERIES (GROUP 5).
(*Both sites are under cultivation*).

Serial No.	Depth.	Gravel.*	pH.	Salt (NaCl).	Description.
Kukerin sandy loam—	inches.	%		%	
3107†	0—2	13·3	6·7	Trace	brownish grey gritty sandy loam.
3108	2—5	15·9	7·4	·01	brown gritty clay loam.
3109	5—13	22·7	8·5	·03	brown gritty clay with ferruginous gravel at 11 inches.
3110	13—17	21·7	8·8	·04	brown gritty calcareous clay.
3111	0—2	7·3	7·4	·02	brownish grey gritty sandy loam.
3112	2—15	2·4	8·8	·03	pale yellow grey gritty sandy clay.
3113	15—20	17·2	9·0	·06	pale yellow grey gritty clay with calcareous nodules.
3114	20—25	33·8	9·0	·08	pale yellow grey gritty calcareous clay with dense calcareous nodules.
Kukerin sand—					
3072	0—4	2·6	6·4	Trace	grey loamy sand.
3073	4—9	17·0	7·5	Trace	greyish yellow cementy sandy clay with ferruginous gravel.
3074	9—18	8·8	8·3	·01	greyish yellow sandy clay with dense calcareous nodules.
3075	18—24	34·9	8·6	·01	similar—more calcareous nodules.

* Per cent. of the fine earth plus gravel. † The subsoil at this site is browner than normal and represents a variation within the type.

The soils of the Kukerin series usually produce fair returns of cereals but unless finishing rains are up to the average the occurrence of dummy heads seriously reduces the crop yield.

Group 6.—126 acres.

Apparently intermediate between Group 2 and Group 5 is a group of sandy and gravelly soil types which, in the virgin state, carry wandoo and related vegetation associations. These do not appear to be calcareous in the subsoil although they are apparently formed on the kaolinised horizon of the country rock. Three types have been recognised on the basis of profile characteristics.

Type 6A.

Type 6A is characterised by an accumulation of ferruginous gravel in the subsurface. The typical profile is as follows:—

0-6 inches, pale brownish grey sand with a little ferruginous gravel.

6-18 inches, greyish yellow gravelly sand with gravel increasing with depth.

Below 18 inches, light brown sandy clay.

Type 6B.

A sandy type in which the profile consists of up to 12 inches of grey gritty sand resting on a brownish yellow to yellow cementy sandy clay loam. A little ferruginous gravel may occur in the profile.

Type 6D.

Type 6D shows a deeper surface layer of sand and appears to be forming on an accumulation of sand washed from higher levels. The profile consists of more than 12 inches of grey to light grey gritty sand resting on a light greyish yellow sandy clay loam; red mottlings appear with depth.

Crops on soils of Group 6 are reported to be unthrifty; they do not stool well and usually develop a disease resembling root rot, more especially in a wet season. It is apparent that this soil type is of a very low fertility status.

Group 7.—19 acres.

Sandplain and related soils.

The general profile of the sandplain and related soils on this farm consists of a greyish surface sand resting on a yellow sand with ferruginous gravel in the subsoil. These are of minor importance in this instance and are of relatively low fertility status.

Summary and Conclusions.

A description is given of the principal soil types of a farm in the wheatbelt east of Wagin. On this farm some 25 per cent. of the area is covered by soil types which exhibit acute manganese deficiency symptoms in wheat and oats.

The principal soil type exhibiting manganese deficiency is named the Tinkurrin gravelly sand. Characteristic features are the ashy, powdery nature of the surface and the accumulation of ferruginous and quartz gravel in the subsurface layer. The subsoil is a yellowish brown sandy clay loam showing further clay accumulation with depth.

The soils exhibiting manganese deficiency are associated with the laterite horizon which consists of ferruginous gravel and quartz gravel coated with ferruginous material mixed with loose sand. This lies above the country rock which appears to consist of gneisses, the upper portions of which are more or less kaolinised.

Two main groups of soils have been recognised where the country rock has been exposed. One of these has been described as the Kukerin series, which is a light grey soil, rich in quartz grit. The other group of soils, described as Group 1, generally occupies the lower parts of the farm and appears to be formed on a hornblende gneiss. These are the most productive soils of the farm with respect to production of cereal crops. Four other soil groups of minor importance are described in the text.

The application of manganese sulphate at the rate of 14 lbs. per acre prevents the appearance of manganese deficiency of wheat or oats on the soil types deficient in available manganese. The manganese sulphate is applied mixed with the superphosphate.

Acknowledgments.

Grateful acknowledgment is made of the assistance of Mr. G. H. Burvill in the determination of the soil reactions reported.

The thanks of the authors are tendered to Dr. Dorothy Carroll, of the University of W.A., for the determination of the soil minerals.

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The Small Plague Grasshopper.

(*Austroicetes cruciata, Sauss.*)

WITH SOME NOTES ON EGG PARASITES OCCURRING IN WESTERN AUSTRALIA,

by

C. F. H. JENKINS, Government Entomologist.

In earlier publications of this Department this insect has been referred to as the Plague Locust, *Chortoicetes terminifera* (Newman 1924 and onwards), and the Plague Grasshopper, *Austroicetes jungi*, (Jenkins 1937).

At the Australian Grasshopper Conference held in Melbourne in 1938, the popular names given to various grasshoppers were discussed, and in order to obtain uniformity and avoid as much as possible further confusion, it was decided to use the name Small Plague Grasshopper for the loosely gregarious *Austroicetes cruciata* infesting the dry areas of Western Australia and South Australia, and the term Australian Plague Locust for the more strongly gregarious and migratory species *Chortoicetes terminifera*, often so troublesome in the Eastern States.

Both species occur in Western Australia, but, strangely enough, the Australian Plague Locust does not swarm in this State, or if so, on very rare occasions.

It has been shown that *A. jungi*, Branesik, is a synonym of *A. cruciata*, Sauss (Key 1938).

Breeding Habits.

The grasshopper lays its eggs in almost any kind of soil, so long as it is compact and free from dense cover. Sandy soil and heavily grassed areas are avoided, as is dense forest and scrub country, but sparsely timbered land or narrow timber belts with bare open patches often afford good nesting sites. Roadsides, railway embankments, reserves, commonages and similar hard undisturbed localities are favourite breeding areas.

The female bores into the ground by means of hard chitinous valves situated at the end of the abdomen and a frothy substance is exuded as a lubricant during the operation and to form a lining to the egg pod.

A large number of males crowd around the female while she is laying and these clumps of yellow males are quite easily picked out during the laying period. About 20 eggs are placed in each pod. They are yellowish white in colour, slightly crescent shaped and about 3/16ths of an inch in length. The mouth of the egg pod is capped with soil cemented together by the frothy secretion exuded by the female and this cap is bodily lifted when the young hoppers emerge. The pod measures a little under $^3/_4$ in. in length.

Larval Stages.

When it first issues from the egg the young hopper is clothed in a tight fitting white sheath and the larva is known as the vermiform lava because it can only progress by means of worm-like wriggles. Almost immediately after hatching, the vermiform larva undergoes what is known as the intermediate moult and the little white casts can often be seen close by the holes from which the hoppers have emerged. The hopper is now said to be in its first larval instar and resembles the adult, save for the fact that it is very small and lacks wings. At first it is light in

colour, but very soon changes to a brown of varying intensity. Five larval instars are passed through, the insects changing from one to the other by means of an ecdysis or moult, until the final winged stage is reached.

Period of Emergence and Duration of Life.

The laying period varies according to seasonal conditions, but may extend from September to November. Only one generation occurs per annum and the progeny from the spring laying do not emerge until about the following July.

The pre-winged stage occupies approximately eight weeks, so that hoppers issuing at the end of July will be mature by the end of September, and as adults, they may live another six weeks.

Hatching may extend over a period of several weeks, the weather conditions having an important influence upon the rate of emergence. Due to this fact hoppers in various stages of development may be present in one area.

The grasshoppers display gregarious tendencies throughout life, clustering together, especially when dull or windy weather conditions are prevailing. In the later instars this gregarious tendency becomes more pronounced, and just before maturity the hoppers may be seen moving in bands or armies as if with a definite purpose in view.

NATURAL ENEMIES.

Egg Parasites.

Bombylid Fly.

Two egg parasites have so far been recorded from Western Australia, but by far the most common noted is a species of Bombylid Fly (*Crytomorpha flaviscutellaris*).

The larvae of this fly are creamy coloured grubs, tapering at each end and when undisturbed they adopt a characteristic curled-up attitude with the head almost touching the tail. Each segment is clearly marked off from its neighbour by a yellowish line.

At this stage the larvae are apparently unable to move about and are found either ensconced in a grasshopper egg pod or curled up in the soil near same.

This insect has been collected in most of the grasshopper infested areas, but the larvae were first discovered and forwarded to this Department by Messrs. Hutchinson and Herbert from egg beds at Nungarin. Material from this locality later reached the Council for Scientific and Industrial Research and was described by Mary Fuller (1938).

The larval life is a long one, for grubs collected by the author in May and July when kept in the laboratory under room temperature emerged in December and January respectively, after a pupal period of about three weeks. The larvae were quite without food over that period during which they lay half buried in sand and were slightly moistened with water from time to time.

Adult.

The adult female (Roberts 1929) is about the size of the common house fly, but has a more globular shaped body. The head and thorax are dark in colour, and the abdomen yellowish, bearing a number of short, erect hairs.

Wasp Parasite.

For several years a careful search has been made for signs of a wasp parasite such as attacks the eggs of grasshoppers in the Eastern States and South Australia, but not until last year were any signs of such a wasp obtained.

Grasshopper eggs collected at Bindi Bindi in November 1939 and at North Westonia in May, 1940, produced a number of small wasps, kindly identified by Mr. A. P. Dodd as *Scelio chortoicetes.* This species has been recorded from the Small Plague Grasshopper elsewhere in Australia, but the present record is, as far as I am aware, the first for this State. The fact that it has not been found earlier, however, shows that it is not numerous and so, unfortunately, is not likely to play any significant part in the control of the pest.

General Description.

The adult female wasp is a tiny, shiny black insect, approximately 3/16ths of an inch in length. The legs are redd'sh brown, the antennae 12 segmented, and the fore-wings slightly clouded.

Egg Laying and Emergence.

The eggs of the Australian Plague Locust, *Chortoicetes terminifera,* in Eastern Australia are attacked by a wasp, *S. fulgidus,* closely resembling the local parasite, and it may be presumed that the method of attack is very similar.

"During egg laying, adult parasites are to be seen running about amongst the laying grasshoppers.

"Sometimes the parasites crawl beneath the thorax of the laying grasshopper and there await the completion of oviposition, when the parasite immediately makes its way down to the grasshopper eggs.

"If earth has fallen into the tunnel, the wasp uses all six legs to dig down until it reaches the dried secretion above the egg pod.

"The adult wasp makes an opening in one end of the egg and forces its way up to the surface of the soil, emerging through a small irregular hole in the soil. Where parasites are abundant, the surface of the ground may be marked by millions of these minute emergence holes which are in marked contrast to the large circular holes through which the young hoppers emerge from the soil." (Noble, 1938.)

Effect of Parasites.

As far as this State is concerned, neither of the egg parasites mentioned can be regarded as of very great economic importance. The heaviest infestation of egg pods with Bombylid larvae would not exceed 15 per cent, while the wasp parasite is as yet of nothing more than academic interest.

CONTROL MEASURES.

Preventive Methods.

Timber in its natural state presents quite an effective barrier against grasshopper infestation and wholesale clearing, and ring-barking for this reason should be deprecated, not to mention its effect upon the bird population and soil erosion. Every effort should be made to cultivate bare hard soil to render it unsuitable for egg laying. Known egg beds should be broken up as finely as possible to a depth of at least 2½ inches, thus fracturing the egg tubes and exposing the eggs to the elements and various natural enemies.

Cultural Methods.

The efficacy of ploughing and allied cultural methods as a means of grasshopper control has been viewed with suspicion by many authorities, but following the severe grasshopper plagues experienced in 1936, it was realised that

drastic methods would have to be adopted to stem the advance of the pest, and a comprehensive scheme was undertaken by the Western Australian Government. Since 1937 many thousands of acres have been broken up by mouldboard and disc ploughs, as well as by fixed tyne cultivators. Ample evidence of the effect of this work upon the resultant hopper population has been gained by comparing the progeny arising from cultivated and non-cultivated fields and by estimating damage done to crops adjoining broken and non-broken country. Where in a few cases the work has been done badly and clods and hard patches have been left, a number of hoppers have survived, but this only strengthened the contention that where the work is properly done effective control can be expected. Even after the grasshoppers have commenced hatching, mouldboard and disc ploughs and sundercuts have been used to advantage, as they turned over the soil and buried most of the hoppers, as well as the food supply of any which might have survived.

In the few cases brought to notice where cultivation was said to have been useless as a means of control, investigation showed that the work had been done late in the season when the hoppers were emerging, and with fixed tyne cultivators. These machines do not turn the land over but merely break it up, and so although for pulverising the surface and destroying egg-beds they are very effective, they are less useful at a later stage when it is necessary to bury the young hoppers and also the weeds which will supply the insects with the necessary energy to move from the fallowed ground.

The ability of young hoppers to live without food is remarkable, and under laboratory conditions they were found to survive for 10 days without nourishment, but upon moist blotting paper. After four days, however, they showed little activity, and it is unlikely that exposed to field conditions they would live more than a week or be able to travel far. Bearing this in mind, therefore, the importance of clean fallow, and where possible the advisability of working round and round a paddock so as to confine the hoppers to the centre, will be apparent.

Typical grasshopper country, north-eastern wheatbelt. [C.F.H.J.]

BAITING AND SPRAYING.

Non-poisonous Sprays.

As a contact spray, Burford's household carbolic soap and Sunlight soap were found to be very effective against hoppers up to the third laval stage. Burford's soap was used at the rate of 2½ ozs. to the gallon, and Sunlight soap at 2 ozs. to the gallon. Either should be mixed with hot water and applied while hot. The best time for spraying is early in the morning when the hoppers are sluggish.

Poison Spray.

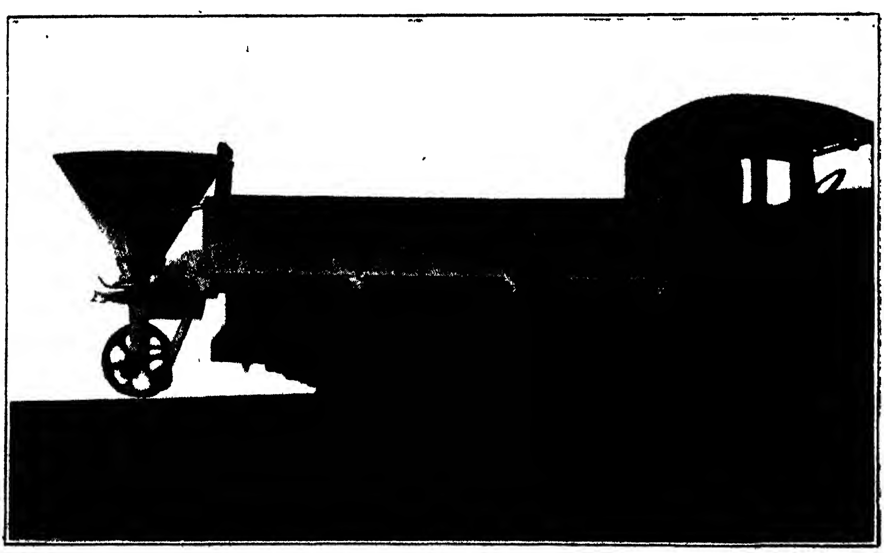
Arsenite of Soda, 1 lb.
Molasses, 4 lbs.
Water, 14 gallons.

This spray kills both by contact, due to the absorption of arsenic through the body integument of the insect, and also by the ingestion of sprayed foliage. It is particularly effective against young hoppers where green herbage is plentiful as is often the case early in the season.

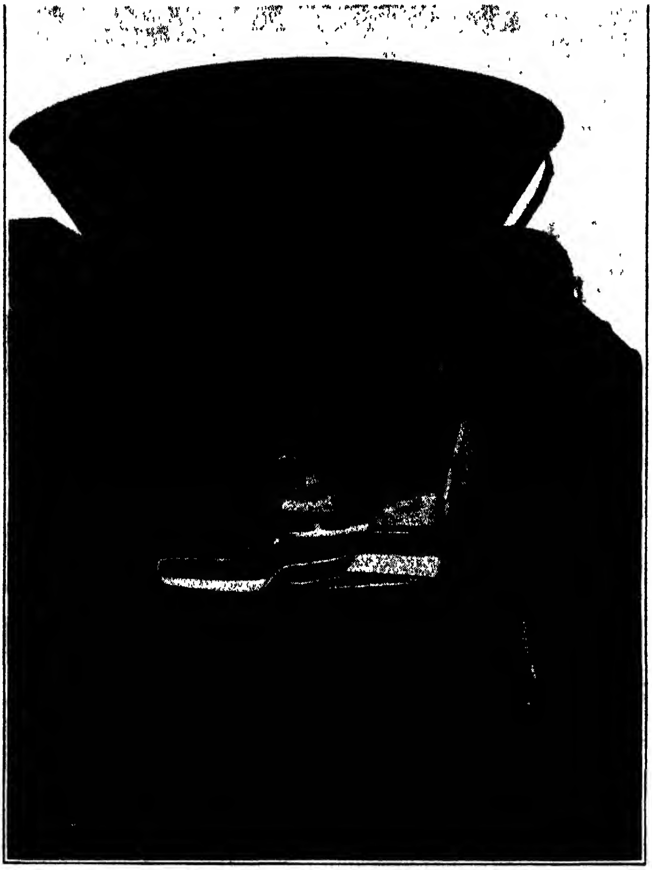
Poison Bait.

Bran, 25 lbs.
Arsenite of Soda, ½ lb. (80 per cent. arsenious oxide).
Molasses, 6 lbs.
Water, 2½ gallons.

The above amount is sufficient to treat one acre. The arsenite of soda should be dissolved in water, likewise the molasses; the two should then be thoroughly mixed into the bran with sufficient additional water to make a moist crumbling mash. The amount of water required to bring this about may vary with different samples of bran but it is essential that the mixture is not allowed to become too wet, otherwise it will become lumpy and correct distribution will be impossible. It is best to thoroughly mix the ingredients and gradually add the water, rather than pour in the estimated quantity all at once, as an even mixture is difficult to obtain if the latter procedure is followed. Unless a broadcaster such as is des-



Bait-spreader attached to truck. [C.F.H.J.]
The chain drive to the backwheel has been removed.

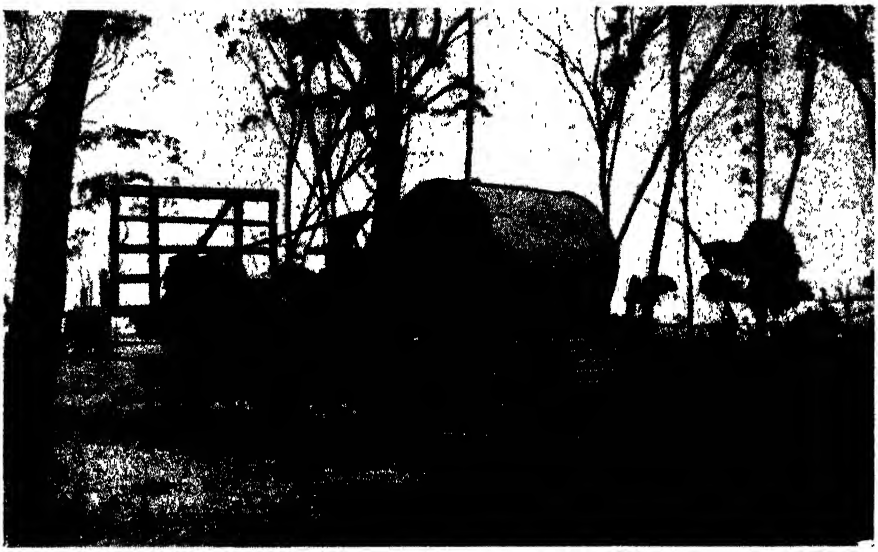


Spreader showing revolving plate and veins for throwing bait.
[C F H J]

cribed below is to be used the bait is best laid by hand, the mixture being thrown into the wind with a flick of the wrist so as to ensure that it will fall in fine particles. Baiting should be done in the early morning before the hoppers have commenced feeding.

During the 1936 campaign in the Narembeen Road Board area, it was demonstrated that the poison bait could be effectively distributed per medium of super-spreaders. Two of these machines were brought into use on the property of Mr. W. N. Hedges. They were mounted on motor lorries and driven by a cog chain connected to the back wheel of the motor. The distribution of the bait by this means assured that it was scattered in the necessary fine particles, lumps being impossible. Mr. Hedges also devised a means of mechanically mixing the baiting ingredients.

This consisted of a circular drum or tank, which rotated about an axle fitted with a number of fixed arms or agitators. The tank was rotated by a belt attached to a small motor. By the use of these methods, much manual labour and man-handling of the baiting material is eliminated. In subsequent campaigns broad-casters have been used in almost all districts with great success and have proved themselves the most effective means of baiting large areas of country.



Power driven bait-mixer. [W.N H.]

Danger to Stock.

Lumpy bait is a constant menace to stock just as long as the lumps remain. If the bait is laid carefully there is little or no danger to stock, but as a precaution it is advisable to remove stock from poisoned paddocks for a fortnight or three weeks. Experiments conducted by the New South Wales Department of Agriculture have shown that where the spray is used, no danger to stock is incurred even if they are allowed immediate access to treated herbage.

Mixing Precautions.

When mixing arsenical solutions, care should be taken to keep the hands as free from the substance as possible, otherwise sores may result. Smearing the hands with grease of any kind before commencing operations will greatly minimise this danger. All receptacles should be carefully washed after having been used for mixing purposes.

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M. T. Padbury Trophy Wheat Yields Competition.

I. THOMAS, Superintendent of Wheat Farming.

This competition, which was for a period of 10 years, commencing with the 1930-31 season, was made possible by a generous donation by Mr. M. T. Padbury, a pioneer farmer in the Moora district. The trophy consists of a handsome jarrah shield having a raised oval centre carrying all the silver ornamentation and including the inscription "The M. T. Padbury Trophy for the Greatest Yield of Wheat per inch of Rainfall during Growing Season."

Under the conditions of the competition, the trophy is to be awarded to the competitor who obtained the greatest mean average acre yield per inch of growing period rainfall, computed from the results of the five seasons in which the competitor obtained his highest acre yield per inch of growing period rainfall. During the period of the competition, each annual winner, besides having his name engraved on the shield, was presented with a replica of the trophy.

The conditions under which the competition was conducted were as follow:—

1. The competition will commence with the 1930-31 harvest and continue for a period of 10 years. At the end of that period the trophy will be awarded to the competitor who has taken part in the competition for at least five years, and who obtains the greatest *mean* average, acre yield per inch of rainfall during the conventional growing period. The mean average yield will be computed from the *results* of the five seasons in which the competitor produced the *highest acre yield per inch* of rainfall during the growing period. In the event of a tie the competition will continue between the leading competitors until an advantage is gained by one of them.

2. The conventional growing period for any year will be that decided upon and announced by the Royal Agricultural Society. For the first year and until further notice it has been decided that it will be from May 1st to October 31st, inclusive.

3. Until the end of the competition the trophy will be in the custody of The Royal Agricultural Society, and will be displayed at any agricultural exhibition held by that society.

4. Each year the competitor who obtains the best average acre yield per inch of rainfall during the conventional growing period will be awarded a replica of the trophy. His name will also be inscribed upon a small shield affixed to the trophy.

5. The rainfall upon which the award will be made will be determined by the Commonwealth Meteorologist from the district records, and his decision in this matter will be final.

6. The competition will be limited to those farmers who harvest at least 200 acres of wheat for grain. Where a competitor is financially interested in the crops grown on one or more farms, he will be required to supply details regarding the production and marketing of the crops on same, and though usually the award will be made upon the results from the farm nominated by the competitor, yet The Royal Agricultural Society may require that the crops on these farms be included in the competing area.

7. The average yield will be ascertained from the total area—including self-sown crops—harvested for grain, and determined from the actual amount of wheat sold as shown by the delivery dockets, plus the amount retained for seed, for home use or for any other purpose.

8. The method of judging will be as follows:—At a convenient time the area harvested for grain will be measured and the quantity of wheat on hand ascertained. On or before January 31st, the farmer will be required to furnish the judge with a sworn declaration as to the quantity of wheat sold from the competing holding or holdings, and the amount retained for seed and other purposes; the statement regarding the amount sold to be supported by agents' dockets. The judge, after satisfying himself as to the correctness of this statement, will compute the average yield per acre per inch of rainfall during the growing period from the information received.

9. The judge will be appointed by the Under-Secretary for Agriculture, and his decision will be final.

10. Nominations for this competition will be received by the Royal Agricultural Society up to the 31st October each year.

The winner of the 1939-40 competition was Mr. P. Strange, of Yarding, with an average of 2 bushels 6 lb. per inch of rainfall from an area of 304 acres. Mr. N. A. Scadding, of Kulin, filled second place with 2 bushels 1 lb. over 545 acres, and was followed by Mr. E. W. Prowse, of Doodlakine, with 1 bushel 47 lb. over 492 acres.

As a result of the more favourable rainfall during the season, despite the dry September, the actual average yields per acre for the seven competitors was higher than for the preceding year, being 21 bushels 42 lbs. per acre compared with 17 bushels 19 lbs. per acre in 1938, but the average yield per inch of rainfall during the growing period was lower, being 1 bushel 44 lbs. as compared to 2 bushels 18 lbs. the previous year.

The detailed results for the 1939-40 season are given in the table below:—

Competitor	Address.	Rainfall during Growing Period.	Area Harvested	Yield: Gross		Yield: Average per Acre.		Yield: Average per Inch Growing Period Rainfall.	
		Points	acres	bus	lb	bus.	lb	bus.	lb.
Strange, P.	Yarding	1,113	304	7,115	48	23	24	2	6
Scadding, N. A	Kulin	1,360	545	14,844	12	27	14	2	1
Prowse, E. W.	Doodlakine	1,161	492	10,830	49	22	1	1	57
Bremner & Sons, J R.	Corrigin	1,327	910	21,685	54	23	36	1	47
Nottage, R. B	Tammin	1,320	594	13,102	25	22	3	1	40
Barr, D. F.	Shackleton	1,154	575	9,440	33	16	25	1	25
Atkins, J L.	Miling	1 605	812	15,055	47	18	32	1	14

The finalising of the results for the 1939-40 season brings this competition to a conclusion, and the following table shows each annual winner, together with their location and average yields:—

Year.	Competitor.	Address.	Yield: Average per Acre.		Yield: Average per Inch Growing Period Rainfall	
			bus.	lb.	bus.	lb.
1930	Williams, F. A.	Mangowine	27	5	3	23
1931	Atkins, J. L.	Jouerdine	19	27	3	0
1932	Butcher, O J.	Pithara	31	12	2	42
1933	Atkins, J. L.	Jouerdine	22	47	3	39
1934	Atkins, J. L.	Jouerdine	18	49	4	20
1935	Moore, Hon. T.	Indarra	24	11	4	6
1936	West, F. C.	Toompup	28	52	2	56
1937	Jones, R. M.	Shackleton	21	42	3	16
1938	Moore, Hon. T.	Indarra	23	54	4	9
1939	Strange, P.	Yarding	23	24	2	6

During the 10 years of the Competition, there were 69 participants, but of these only 12 competed for the stipulated five or more years.

In the table hereunder are set out the mean average results computed from those of the five seasons in which the 12 finalists obtained their highest acre yield per inch of growing period rainfall, together with the total number of years in which they competed.

Final Award and Results for those Competitors competing for Five or more Years.

Average Results for Best Five Years.

Competitor.	Address.	Average Area Harvested.	Yield.				No. of Years Competing.
			Average per Acre.		Average per Inch Growing Period Rainfall.		
		Acres.	bus.	lb.	bus.	lb.	
Moore, Hon. T.	Indarra	255·2	27	37	3	26	6
Atkins, J. L.	Jouerdine and Miling	474·5	19	54	3	1	5
Nottage, R. B.	Tammin	354·5	27	45	2	51	5
White, R. H.	Gnowangerup	274·4	28	30	2	30	5
Strange, P.	Yarding	349·8	23	17	2	26	6
Manuel, C. J.	Mukinbudin	416·1	18	7	2	26	5
Stewart, W. B.	Gnowangerup	235·0	27	42	2	22	5
Bremner & Sons, J. R.	Corrigin	955·2	20	47	2	21	10
Scadding, N. A.	Kulin	480·7	25	41	2	20	7
Creagh Bros.	Nungarin	1,019·6	17	53	2	19	[illegible]
Prowse, E. W.	Doodlakine	549·6	17	53	2	13	5
Barr, D. F.	Shackleton	511·1	17	38	1	56	5

Though the majority of these finalists were located in the more eastern wheat belt, they included entrants from the Great Southern and the Northern districts.

In determining the ultimate winner, the mean was computed from the results of the five best seasons for each finalist by averaging the acre yields per inch of rainfall for those five seasons.

The winner of the trophy was the Hon. T. Moore, M.L.C., of Indarra, who obtained the very excellent average of 3 bushels 26 lb. per inch of rainfall, and was closely followed by Mr. J. L. Atkins, formerly of Jouerdine, with 3 bushels 1 lb. Mr. R. B. Nottage of Tammin was a close third with 2 bushels 51 lb.

The performance of all finalists was highly meritorious having special regard to the seasonal conditions during the period under review. It will also be noted from the above table that only one competitor, Messrs. J. R. Bremner & Sons of Corrigin participated every year. This competitor obtained the excellent mean average acre yield of 2 bushels 6 lb. per inch of rainfall and an actual average yield per acre of 20 bushels 56 lb. for the *whole ten year* period from an average acreage of 942 acres.

During the 10-year period of the competition, the average yield per acre of all 69 competitors was 21 bushels 43 lb. The State's average yield for the same period was 11 bushels 36 lb.

With the close of this Competition a brief review of the farming and cultural practices generally adopted by the competitors is of interest.

A summary of the cultural practices, etc., of the finalists, from whom information was available, is given in the accompanying table:—

CULTURAL DETAILS OF FINALISTS.

Competitor.	Vegetation and Soil.	Implements, etc.	Cultural Practices.	Seeding.	Varieties.	Other Crops.	Sheep.
Moore, Hon. T., Indarra	York gum, jam Red brown loam overlaying clay subsoil	Disc-cultivating plough, spring-tyne cultivator, combine cultivator drill Horses	3-year rotation, early Winter fallowing spring cultivation and before seeding, in summer only when necessary	Crops mainly seeded dry, little weed trouble due to clean fallow, graded and pickled seed 45 lb. per acre, super 100 lb. per acre	Bencubbin up to 1934. Merredin. Ranee and Dundee	Oats	Yes
Atkins, J. L.—Jouerdine ..	Salmon gum gimlet Heavy clay	Tractor, mouldboard and disc cultivating ploughs, spring-tyne cultivator, combine-cultivator drill	Early winter fallowing, fallow disturbed as little as possible on account of setting and erosion	Seeded April-May according to variety: graded and pickled seed 37–40 lb. per acre, super. 100 lb. per acre	Bencubbin, Gluyas Early, Noongaar		
Miling	York gum	Disc-cultivating plough, spring-tyne cultivator, combine-cultivator drill	Early winter fallowing, spring cultivation and prior to seeding with combine	Seeded May: graded and pickled seed 53 lb. per acre, super. 112 lb. per acre	Bencubbin, Gluclub, Noongaar not suitable in this district	.. ..	Yes
Nottage, R. B., Tammin	Gimlet Clay and loam	Disc-cultivating plough, scarifier, rigid-tyne combine-cultivator drill, Tractor	3-year rotation, early winter fallowing with disc, 2nd working with rigid-tyne cultivator and again before seeding, light harrows on drill	Seeded mid-April-May; graded and pickled seed 45 lb. per acre, super 90 lb per acre	Bencubbin, Noongaar, Totadgin	Oats—partly for control of Take-all	Yes
Strange, P., Yarding	Salmon gum, gimlet, York gum, jam and scrub Mixed soil types, some wodjil	Disc-cultivating plough, scarifier, combine cultivator drill Horses	Six-year rotation, fallow wheat fallow wheat oats pasture: early winter fallowing with disc: for some years a second discing given, latterly used scarifier: cultivated prior to seeding	Seeded mid-April-late May; graded and pickled seed 50 lb. per acre, super. 100 lb. per acre	Gluclub, Bencubbin	Oats—for grain, hay and green feed; small area Sudan Grass	Yes
Manuel, C. J., Mukinbudin	Salmon gum, gimlet and morrell Heavy red clay	Disc-cultivating plough, spring-tyne cultivator, disc drill till 1933, combine cultivator drill Horses till 1934 then horses and tractor	2-year rotation, winter fallowing: spring-tyne cultivated in spring and prior to seeding	Seeded late April-May; graded and pickled seed 45 lb. per acre, super. 80 lb. per acre	Gluyas Early, Totadgin	Oats	Yes

[illegible], W. D., [illegible]angerup	York gum, morrell, salmon gum, jam, mort, mallee. Red loam, grey loam, some clay	Mouldboard plough. spring-tyne cultivator. spring-tyne combine. cultivator drill. Horses.	Rotation—Fallow wheat [illegible] or 3 years pasture, sometimes includes crop of oats or lucerne or both. early winter fallowing (mouldboard), spring-tyne cultivated twice in spring, after Autumn rains and before seeding with combine	Seeded mid-May-June; graded and pickled seed 48 lb. per acre. super. 112 lb. per acre	[illegible] King and Nabawa during early years, then Bencubbin and Free Gallipoli, now Bencubbin and Nabawa	Oats, barley, lucerne; wimmera rye with cereal crops	Yes
Bremner & Sons, Corrigin	York gum, salmon gum, morrell, gimlet, jam and mallee. Heavy clay, light loams and sand	Scarifier, spring-tyne cultivator, combine-cultivator drill, light harrows. Horses and tractor	Mainly 2-year rotation, now intending to widen rotation considerably. early winter fallowing with scarifier two further scarifyings before spring, spring-tyne cultivation before seeding	Seeded during April-May; graded and pickled seed 50 lb. per acre. super 145 lb. per acre	Gluyas Early during early years, now mostly Bencubbin	Oats, barley	Yes
Scadding, N. A., Kulin	Tea-tree, morrell, gimlet. Heavy and light land	Disc-cultivating plough, spring-tyne cultivator, combine cultivator drill. Tractor	Two-year rotation till 1936, then widened considerably: early winter fallowing Spring-tyne cultivated in spring and prior to seeding	Seeded mid-April mid-May, graded and pickled seed 60lb. per acre, super. 120lb. per acre	Bencubbin, Gluclub, Totadgin, Pusa IV.	Oats	Yes.
Creagh Bros., Nungarin	Salmon gum, gimlet, whitegum, mallee and boree. Heavy clay, clay loam, sandy loam	Disc-cultivating plough scarifier, spring-tyne cultivator, combine cultivator drill. Tractor	Three-year rotation, fallow, crop, pasture ploughed June, July, August scarifier or spring-tyne cultivation in Spring and before seeding	Seeded all on fallow early May-early June, graded and pickled seed 45lb. per acre, super. 90lb. per acre	Bencubbin, Noongaar, Gluyas Early, Carrabin	Oats; small area top-dressed	Yes.
Prowse, E. W., Doodlakine	Salmon gum, gimlet and scrub. Mainly heavy land	Disc-cultivating plough scarifier, combine cultivator drill. Horses and tractor	Three-year rotation during early years. Altered to heavy land, modified 3-year rotation, light land, 4-year, fallow, wheat, oats fed off, pasture early winter fallowing with scarifier in 2-year rotation, disc after being under pasture cultivated in Spring and prior to seeding	Seeded late April-May, graded and pickled seed 45lb. per acre. super. 100lb. per acre	Gluclub, Bencubbin, Totadgin, Noongaar	Oats	Yes.
Barr, D. F., Shackleton	Gimlet, salmon gum, tea-tree, mallee and scrub. Heavy and light land	Mouldboard, heavy disc cultivating plough, scarifier, spring-tyne cultivator, combine cultivator drill, light harrows. Horses and tractor	Two-year rotation in early years, now 3-year early winter fallow, Spring-tyne cultivated in Spring and prior to seeding	Seeded late April-May-June, graded and pickled seed 45lb. per acre, super. 90lb. per acre	Bencubbin, Gluclub, Noongaar		Yes.

The farming methods adopted closely follow the results of the lessons to be learnt from the experiments conducted at the several Research Stations. The application of these varied according to the rainfall, but the following general principles apply to both the heavier and lighter rainfall areas:—

(1) Plant the wheat crop on land which has been fallowed.

(2) Carry out the initial operation of fallowing (ploughing) during the early winter months to a depth of from 3-4 inches.

(3) Cultivate the ploughed land to a full depth of ploughing, preferably with a tyne implement, during the spring months, to form a soil mulch and destroy weed growth.

(4) Depasture sheep on the area to be fallowed, during fallowing and after being fallowed, to control weed growth.

(5) Disturb the fallow as little as possible during the summer months, except when necessary to destroy weed growth and maintain the mulch.

(6) Cultivate following upon rains in Autumn, prior to seeding; this cultivation should not be deeper than is sufficient to efficiently destroy weed growth, otherwise the consolidation of the seed-bed will be interfered with.

(7) Use clean graded seed wheat of suitable maturing and disease-resisting varieties. For the prevention of the disease Ball Smut, the seed requires to be treated with Copper Carbonate or other suitable fungicide.

(8) Plant at the correct depth, namely 1½-2 inches, on a well consolidated seedbed.

(9) It is essential that the different maturing varieties be planted at the correct time in accordance with their seasonal maturity, i.e., the late maturing varieties early in the season, followed by the mid-season maturing varieties, and these followed by the early and very early maturing varieties.

In the lower rainfall areas seeding should be completed by the end of May, and in the more favoured rainfall areas not later than the first or second week in June.

(10) The rate of seeding in the lower rainfall areas is approximately 45 lb. per acre, and the wetter districts up to 60 lb. per acre, together with a liberal application of superphosphate, up to 1 cwt. on the heavier soils, and from 120 lb. on the lighter and sandier types.

(11) The crop rotation on the farm should be such that will enable the maximum number of stock to be carried, and which will improve and conserve the fertility of the soil and assist to control diseases such as flagsmut and take-all, and in this direction what is known as the modified three-year rotation is recommended—crop and fallow for a period of 6 years, followed by a period of pasture of 4-6 years. This rotation can be modified to include more pasture years, depending upon the total area of the farm and the area under cereal crop. When planting the crop, prior to the land being allowed to return to pasture, pasture seeds, preferably of leguminous species, should also be sown so as to provide improved pasture in subsequent years.

(12) It cannot be over-emphasised that when carrying out the various cultural operations, they should be carried out at the right time, the job done thoroughly, and in the most efficient manner. To do this, the implements must, at all times, be maintained in good order.

A perusal of the results obtained by the competitors show that the yields obtained were highly meritorious, and many of the participants attribute their success in achieving such to closely adopting and carrying out these basic principles.

More Pigs in the North-Eastern Wheat Belt.

W. M. NUNN, Agricultural Adviser, Kununoppin.

For some years the comparatively recently opened up North-Eastern wheat belt remained a purely wheat growing area. There was a natural trend, of course, toward mixed farming, but while satisfactory returns were being obtained from wheat growing, the development was slow and the tendency everywhere was to produce more and more wheat rather than to provide conveniences for the running of more stock.

With the recent run of dry seasons and of low prices, returns from wheat growing have been less satisfactory and the development of mixed farming methods has been considerably hastened. The progressive farmer is not content to rely on returns from wheat alone. He is giving more and more time and attention to the building up and management of a flock of sheep, and in many instances to the establishment of a herd of pigs.

There is no doubt that sheep are really essential to the successful management of the farm. They not only provide extra income from wool and lamb returns; they supplement farm workings in the cropping programme and are necessary to every intelligent system of crop rotation. With the assistance given by the Agricultural Bank in recent years practically all farmers have made, or are about to make, a start with sheep.

Pigs also are profitable and those who have their wheat cropping and their sheep management nicely co-ordinated and who can provide the labour and conveniences for the correct management of a herd of pigs, should give careful thought to the possibilities offered by the export bacon market. We do not know what price to expect for the coming season's wheat, but anticipations with regard to export bacon prices, however, are considerably brighter. The day is gone when local supplies affected prices and we have a steady demand for export bacon carcases at prices guaranteed by the British Government. Wheat is a satisfactory feed for pigs, if suitably supplemented, and it is far more profitably disposed of by turning it into bacon than by selling it as grain.

Experiments carried out at Muresk Agricultural College in 1938 by H. J. Hughes and C. R. Dixon and published in the March, 1939, issue of this Journal (1), arrived at very interesting figures regarding the costs of feeding pigs on wheat with protein supplemented in several different forms. Using these figures as a basis of calculation the Superintendent of Dairying has shown in recently delivered lectures that at the present guaranteed prices for export bacon, wheat should return 7/- gross per bushel to the grower who sells it as bacon. The net return would vary according to the charges made for labour, capital expenditure, rent and whether the pigs were bought or bred on the farm.

It is not intended here to set out proof as to the correctness of this figure based upon experimental results obtained in 1938. The prices of protein supplements have altered slightly since then and will alter again: the price guarantee for bacon may be altered when reconsidered in June, but it is suggested that even if the price for bacon pigs were lowered by as much as twopence per pound, wheat would return something like 4/6 or 5/ per bushel gross if sold through the pig.

There are perhaps more pitfalls in pig-breeding than in any other branch of mixed farming—particularly in those districts, for which this article is intended, where conditions are not naturally suited to pigs and where the be-

ginner is surrounded by beginners. The farmer frequently buys pigs because he feels there is money in them. He has perhaps never seen a correctly laid out and managed pig farm and soon, as a result of improper sanitation, mismanagement or poor feeding methods, his pigs are in unthrifty condition: they are unprofitable, and his venture has become a failure.

This article is intended firstly as an urge to wheat-belt farmers to go in for pigs—they are profitable—and secondly as a warning to them that the job must be done properly if it is to be attended by success. Farmers are encouraged to write to the Department of Agriculture for Leaflet No. 496 (2), which deals more fully with the breeding and management of pigs, but some important factors are summarised below to assist beginners in steering clear of the many pitfalls open to them.

Yards.

It is essential that the pig be provided with clean, roomy and warm quarters. Avoid the old method of imprisoning the animals in poky sties which cannot be kept clean. Almost every ailment the pig is capable of contracting is aggravated by unclean conditions, and if any trouble of an infectious nature is introduced, it is under these conditions that its spread is most devastating. Provide them with roomy yards on a well-drained site with warm draught-proof shelters for sleeping.

Above all, see that the yards are ready before the pigs are obtained or you may never have time to go ahead with the construction.

Type of Pig.

The Tamworth and the Improved Berkshire have consistently shown themselves to be most suitable for wheat-belt conditions, but whatever breed is used it is essential to select animals which conform to the bacon type required by the English market if export carcases are to be produced. The carcase required is the leaner type showing good length, light shoulder, well developed lengthy ham, light jowl and small head. Avoid the old fashioned, short, dumpy pig, with its short, overfat ham, short side, heavy fat shouder and very fat jowl.

Feeding.

Wheat is, of course, the basis of the ration throughout the wheat belt, but it must be supplemented with some form of protein—a muscle and bone-forming material which is present in wheat but not in sufficient quantity, and with some form of calcium—the only essential mineral requirement which is not supplied by wheat. Pigs fed on wheat alone very soon show evidence of protein deficiency. Troubles at farrowing, small litters, litters born dead and stunted growth in survivors are ills that can often be traced to protein deficiency. Even if such extremes are avoided, the pig which is fed on wheat alone stands very little chance of producing a good bacon carcase because, with insufficient protein, the growth of the body is handicapped; fat is laid on at the expense of lean meat and bone, and the short, fat type of carcase, which is not wanted by the market, is the result.

Where skim milk is not available, meat-meal is the most economical protein supplement. To grow good bacon with wheat as the main foodstuff see that you include about 12 per cent. of meat-meal in the weaner's ration; decrease this to 10 per cent. by the time the animal is about 50 lbs. live weight, and after another month when the pig is about porker weight, gradually introduce a little

oaten chaff and increase this up to about 10 per cent. The effect of the chaff is to prevent fat being laid on too heavily in the later stages, and recent experiments and practical experience have shown that it greatly improves the quality of the carcase.

Calcium can easily be supplied by adding 1-2 per cent. of bone-meal or ground limestone to the ration or by adding slaked lime to the drinking water.

The above rations are worked out on the assumption that little or no green feed is available. Pigs do best of all on grazing and if it could be provided most of the troubles now being met by beginners in the wheat areas would be avoided. It is particularly desirable that some green feed or silage should be provided for sows with litters, as it greatly increases lactation and so the health and growth of the young pigs.

Disease.

No discussion which deals with pigs, however briefly, is complete without some mention of the possibility of introducing disease to the herd. The pig is susceptible to so many ailments—swine plague in particular is so common throughout these areas at present—that the farmer should be very careful when purchasing new stock. If he does not know from personal knowledge of the former owner's stock that his purchases are healthy, he should keep them isolated until he is confident that they are not carrying disease which might spread to his other pigs.

Conclusion.

The most profitable way of marketing wheat under present conditions is to feed it to pigs and sell it as export bacon. The indications are that this state of affairs will continue—war or no war—for some time to come. Certainly the wheat farmer lacks certain advantages possessed by the dairy farmer with regard to pastures and supplies of skim milk, but it has already been shown by men who are going into the job thoroughly that pigs can be satisfactorily and profitably run even without these advantages. Furthermore, the dairyman has to buy his grain feeds; the farmer grows them and his concern is to sell to the best advantage.

If attention is given to the above briefly mentioned considerations with regard to management and feeding, and it is remembered that field officers of the Department of Agriculture are ready and eager to assist should trouble arise, no farmer should have any doubt as to the ultimate success of his venture in pigs.

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A Soil Survey of the Lakes District. Western Australia.

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SUMMARY AND CONCLUSIONS.

1. The general physiographic and climatic conditions of the Lakes District and details of the soil types and their chemical, physical and agricultural properties are given.

2. The soil survey covered an area of 228,667 acres over a distance of 70 miles where the average annual rainfall ranges from nearly 14 inches to somewhat less than 11 inches.

3. Ten soil series, subdivided into 20 types and phases, were recognised and named. In addition, a number of miscellaneous types and sub-types were described.

4. The principal soils are typical of the grey and brown solonised soil zone or "mallee" zone.

5. The soil types have been related to the first, second and third classes used under the system of land classification adopted by the Department of Lands and Surveys.

6. The chief potential agricultural soils of the district are those of the salmon gum woodland (32,595 acres), the gimlet thickets (6,696 acres) and the better class mallee scrub (37,533 acres) in which salinity is not high. These soils, covering 76,824 acres in the area examined, resemble the soils of other parts of the wheat belt under similar rainfall conditions.

7. Problem soils are those of the morrel woodland (59,700 acres) and areas of other groups where excessive salinity occurs (28,269 acres).

8. Other soils of low agricultural value are those of the heath and wodjil plains (36,521 acres) and the low-lying, lakey country (18,323 acres). Small lakes and rock outcrops account for 9,030 acres.

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9. The woodland and mallee scrub soils generally are rich in potash, lime and magnesia, normally low in nitrogen and humus and extremely deficient in phosphate.

10. Apart from the morrel woodland and saline areas, the soils are suitable for general mixed farming, with stock raising and wheat production as the chief activities. There is evidence that the problem soils may improve under a programme of pasture production and stock raising. Transport difficulties are serious.

11. Over-stocking and over-cultivation must be carefully avoided to prevent soil erosion and land deterioration.

I. INTRODUCTION.

Following the reconnaissance survey of the main portion of the 3,500 Farms Scheme south of Southern Cross (Teakle, 1939), a more detailed examination was made of an area known as the Lakes District, which lies east of Newdegate but west of No. 1 Rabbit Proof Fence. The location of this area is shown in Figure 1. Settlement in this district was commenced in 1928 as part of the 3,500 Farms Scheme under agreement with the Development and Migration Commission, and good progress was made in the early years when some 203 holdings were selected and improvements initiated. Although the northern portion of the settlement was 55 miles from the railway at Kondinin, and Lake King at the south was 40 miles from the rail head at Newdegate, the apparent prospects for wheat farming attracted many settlers and available holdings were quickly disposed of. It was anticipated that railway services for the proposed 3,500 Farms Scheme would soon be available.

Unfortunately, the agricultural conditions in the Salmon Gums district and the results of the soil examinations to the eastwards were discouraging and the State Government took steps to ascertain the extent of the salinity problem in the Lakes District. A brief reconnaissance, made in May, 1930, showed that soil salinity was a problem of some magnitude and in consequence a more detailed soil survey was commenced in August, 1930. Field work was completed by the end of May, 1931.

The results of this survey served to define the soil conditions in the area, and to give a general picture of the distribution of soil types and the incidence of soil salinity in the district. Less attention was paid to the recognition of soil types in this survey than in subsequent work as the foremost question was that of the incidence of soil salinity. In an area devoted to an extensive type of farming, it is impossible to undertake a soil survey which will give a very detailed picture for every farm. For this purpose a much closer soil examination would have to be made, and such a programme is unwarranted, except, of course, for special investigational work such as may be conducted on research stations. In this survey, an endeavour was made to obtain sufficient data to construct a map which would show the distribution of the main soil types and the general severity of the salinity problem on each farm in the shortest possible time, to meet the needs of those administering the district. Subsequent experience showed that the methods adopted adequately met these requirements and that, intelligently interpreted, the maps prepared should be a valuable guide to the conduct of farming operations in the surveyed area.

The soil survey was used by the Agricultural Bank as a basis for reconstruction of the settlement in 1935 ("West Australian," 25th September, 1935). At that time there were 101 farmers under the Agricultural Bank and eight free

settlers in the district. Practically every settler desired to remain in the district. Reconstruction proposals involved the linking up of holdings and the provision of additional improvements, so that there would be sufficient land for carrying from 800 to 1,000 sheep and an adequate area of suitable soils for a limited programme of wheat production. It was estimated that about £140,000 for additional improvements would be required for the realisation of this purpose.

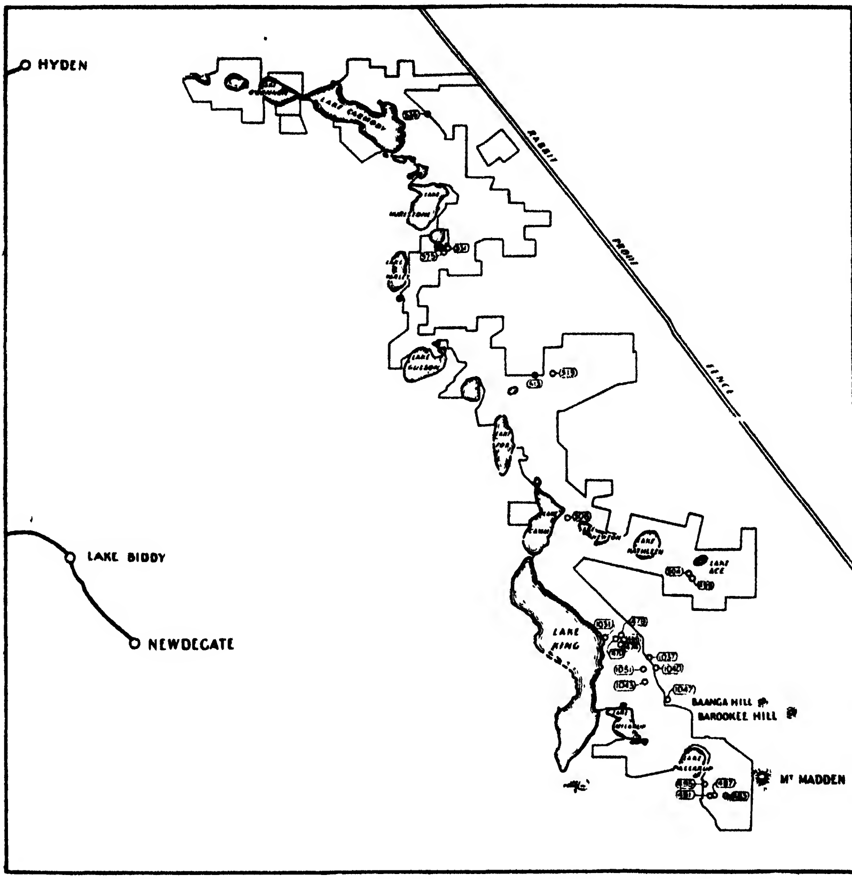

Fig. 1.—Sketch map of the Lakes District showing the rail heads at Hyden and Newdegate and the No. 1 Rabbit Proof Fence. The portion examined in the course of the soil survey is included within the outlined area adjacent to the lake system. The location of sites from which type samples were obtained is shown by the small circles each of which is identified by the serial number of the surface sample. Scale: 1 inch = 14.7 miles (approx.).

II. PHYSIOGRAPHY AND GEOLOGY.

The main settlement lies in a valley running about N.N.W. and S.S.E. in direction and extends over a distance of 70 miles from Lake O'Connor in the north to Lake Pallarup in the south. There can be little doubt that the area represents an old river valley formed in pre-historic times (but during the Tertiary period) when the climate was wetter. With subsequent desiccation, the river channel has been reduced to a chain of salinas, or salt lakes as they are called in Western Australia, and low-lying lakey country. The chief salinas in

the chain have been named and, from north to south, include Lakes O'Connor, Carmody, Gulson, Varley, Camm, King, Milarup and Pallarup. Short tributaries of the old river system are represented by a number of areas of timber country running eastward from the main valley. The most definite of these tributary valleys is occupied by Lake Newton, Lake Kathleen and Lake Ace. No surface flow of water now occurs in these channels.

The salinas and low-lying country generally occupy the extreme western side of the valley, and the farming lands run eastward from these formations to the heath and wodjil country of the old peneplain. The facts that the salinas lie against the western side where the rise is fairly abrupt to the gravelly sandplains of the old peneplain formation, and the main valley floor extends generally from 1-3 miles to the eastward, would suggest that this area had either been tilted slightly downward to the west or that prevailing westerly winds had filled the eastern portion of the valley with detritus, thus forcing the channel against the western shore.

Information derived from railway surveys at Lake Grace and Newdegate indicates that the elevation of the area in the south ranges from about 900 feet on the valley floor, represented by the salinas, to about 1,100 feet on the peneplain. Further north the elevation is somewhat higher as the salinas in the vicinity of Lake O'Connor are about 1,000 feet above sea level.

A diagrammatic representation of a vertical section of the area is shown in Figure 2. As information for Lake King is not available, the data from the Lake Grace Railway survey have been used to illustrate the changes in elevation across the section.

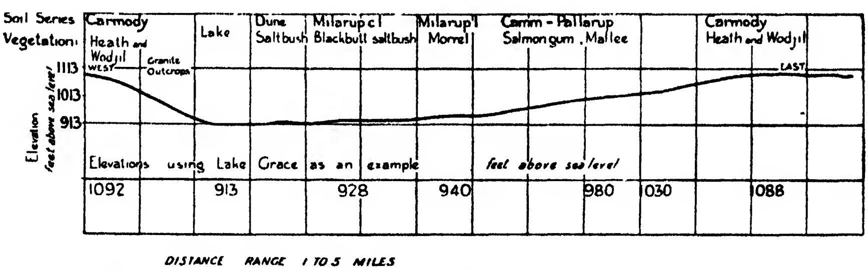

Fig. 2.—Diagrammatic representation of a vertical section of the Lake King valley showing the lake against the relatively steep western side of the valley and the valley floor gradually rising to the east. As no levels are available for Lake King, figures from Lake Grace are quoted as representative of a similar catena. (Figures kindly supplied by Mr. McCulloch of the W.A. Government Railways.)

The valley is senile and both the eastern and western slopes are buttressed by the granitic or gneissic bosses exposed by the erosive agencies which lead to its formation.

The principal geological formations of the area are the pre-Cambrian granites and gneisses typical of the wheat belt generally. As in the more northern agricultural areas, basic dykes or other types of intrusive rocks occur in the pre-Cambrian complex, and give rise to variations in the soil conditions.

While there is little concrete geological evidence, the nature of the soil types in the southern portion of the district suggests the presence of sandstone formations, possibly of the Miocene group observed in the Salmon Gums district, in addition to the pre-Cambrian rocks.

III. CLIMATE.

The climate of the area is typical of the southern wheat belt. The rainfall ranges from an average of nearly 14 inches in the south to about 10½ inches in the north. While the bulk of the precipitation occurs in the winter, a certain amount of summer rain is received and should greatly improve the prospects for pasture production and stock raising as compared with the northern areas of similar annual rainfall. Winter frosts are common but the summer temperatures are tempered somewhat by the southern ocean.

Table 1 gives meteorological information supplied by the Divisional Meteorologist regarding three stations representing the district, and a comparison with the records from the Merredin Research Station and the Salmon Gums Research Station.

TABLE 1.

RAINFALL RECORDS FOR STATIONS IN THE LAKES DISTRICT IN COMPARISON WITH OTHER DISTRICTS.

Station	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct	Nov.	Dec.	Total.
Emu Rock—33 years to 1938	43	34	80	82	139	130	141	158	78	69	67	34	1,055
Lake King—10 years to 1939	93	34	156	73	167	161	188	173	90	133	69	44	1,381
Lake Varley—10 years to 1939	112	42	151	90	162	155	172	178	100	141	62	27	1,392
Merredin Research Station—27 years to 1938	52	44	105	89	127	181	180	152	84	78	41	50	1,183
Salmon Gums Research Station—13 years to 1938	82	55	142	97	134	154	150	165	92	104	96	62	1,333

IV. SOILS.

1. *General.*

The Lakes District lies in the western portion of the Fitzgerald region (Teakle 1938) of the zone of grey and brown calcareous solonised soils of Western Australia. This corresponds to the "mallee" zone described by Prescott (1931). Some of the soil types closely resemble those observed at Salmon Gums, while others exhibit properties more characteristic of the main wheat belt, particularly in the Lake Grace and Newdegate districts. These relationships may be due to the underlying geological formations. Apart from the unusually large proportion of the so-called snuffy morrel country, the surface features indicate that the woodland (or forest*) soils and the principal types carrying mallee scrub are suitable for general wheat farming purposes.

In accordance with the nomenclature suggested by Milne (1935), the soils of the district can be grouped as a cantena or sequence of soils ranging from valley types to the sands and gravels of the high level heaths of the peneplain. This sequence is illustrated diagrammatically in Figure 2.

Neglecting the western side of the valley where the slopes rise more or less abruptly from the salinas and where considerable areas of agricultural soils do not

* More appropriately termed "Woodland."

occur, the following groups of soils are encountered as one proceeds eastwards from the eastern edge of the salinas:—

A. *Soils of the valley floor.*

(1) Salt bush heath soils; immature soils on dunes formed from material blown from the salinas.

(2) Snuffy, grey, calcareous woodland soils:—

(a) the Milarup clay loam, characterised by Kondinin blackbutt* and saltbush.

(b) Milarup loam characterised by morrel and boree as principal elements of the vegetation.

(3) Soils of the salmon gum woodlands; soils of the Camm series and the woodland phase of the Pallarup series cover this area. They range from brown to brownish grey sands and sandy loams with a calcareous, sandy clay subsoil.

B. *Soils of the valley slopes.*

(4) The soils of the valley slopes are chiefly grey and brown sandy types with a calcareous, sandy clay subsoil, which carry generally a vegetation chiefly of mallee scrub. Patches of sandy and gravelly heath and strips of woodland occur in this group.

C. *Soils of the peneplain.*

(5) The grey and yellowish sandy and gravelly soils of the peneplain carry either a heath or a wodjil** vegetation association. These soils are azonal—that is, they do not exhibit the characteristics of the woodland and mallee soils regarded as normal for the zone. Prescott (1931) regards them as relics of a period when the climate was much wetter and when a large proportion of the original plant food was lost as a result of a long period of heavy leaching.

Settlement has been largely confined to the woodland and mallee soils as these are of highest fertility and, in consequence, the soil survey was confined largely to these types.

2. *Soil Survey.*

(a) *Preliminary Investigations.*

Before commencing the soil survey, an examination of the soils of the Newdegate district was made to determine the agricultural value of the principal soils of the district. High tribute is paid to the Agricultural Bank inspector of the district, Mr. G. Birt, who assisted in this examination. Mr. Birt made available his valuable practical experience with respect to the important soil types of the district, and gave sound advice concerning reactions under ordinary wheat farming practice. This examination of the Newdegate district, combined with experience in the Salmon Gums district, provided the basis for the interpretation of the results of the soil survey.

(b) *Soil Survey Technique.*

As the result of a preliminary examination of the soils of the Lakes district, a number of soil types were defined on the basis of profile features. Vegetation, salinity and topography were adopted as subsidiary factors in the soil type definitions. In some instances, the degree of salinity was used as the deciding factor between closely related types of the one series.

* Local names are used where possible. A list of corresponding botanical names is given in the appendix.

**Wodjil in this district is a densely growing acacia which may reach a height of 12-20 feet.

Most of the area still being in the virgin state it proved convenient to conduct the survey on the grid system by means of compass traverses, or transects, along which the soil and vegetation changes were noted and mapped, and along which samples for analysis were taken.

Each party engaged on the traverse work consisted of a technical officer, or soil surveyor, and a chainman. Distances were determined by means of a 5-chain steel tape. Roads and block boundaries, which had been recently surveyed, were used as bases for the work, and copies of compilation plans on the scale of 20 chains equals one inch were used for the construction of the soil maps. Generally, the traverses were run at intervals of 17-20 chains and samples were taken every 10 chains, but the soil surveyor was able to use his discretion regarding the location of sites for sampling and other technical matters determinable only in the field. Thus on the average one site represented about 20 acres, so that no more than a general salinity distribution could be expected from the results.

As a general practice the sites were sampled to a depth of two feet and, in order to obtain data regarding the distribution of salt in the profile, samples were taken to represent both the first foot and second foot layers. In order to avoid the difficulty of mixing two layers which were dissimilar both physically and chemically, the sandy surface, where it occurred, was discarded and the top sample obtained from the subsoil above the 12-inch level. It had already been established that the sandy surface was invariably of very low salinity. When the occasion demanded the site would be examined to greater depths.

During the course of the survey, type samples were obtained to represent the chief soils recognised. These were generally taken from a pit dug for the purpose, so that the nature of the profile could be more closely examined than is possible when the soil auger only is used. The locations of sites selected for type samples are shown on Figure 1.

(c) *Laboratory Investigations.*

As the purpose of the survey was the determination of the incidence of salinity, numerous samples were taken to represent the various soil types. These were analysed for salt content in a field laboratory arranged in a canvas tent using the conductimetric method described by Samuel and Teakle (1931). As a check, the chloride titration method of Best (1929) was used on about 25 per cent. of the samples. A further check on the work was obtained from the analyses of the type samples carried out in the Government Chemical Laboratory in Perth.

(d) *Mapping and Interpretation.*

The salinity determinations were recorded in the field books from laboratory sheets and this information, together with that relating to the soil type and other factors, plotted on the base plans. The first factor considered in the classification was the soil type, as it was considered that the properties on which the definition of a soil type was based would determine the agricultural value as well as the subsequent behaviour of the soil after clearing.

Preliminary work indicated that there was a very close correlation between soil type and degree of salinity in the virgin soils. Generally, the more clayey types were more saline, and, on this basis, highly saline, moderately saline and non-saline types within each soil series were recognised. The maps of the southern portion of the area were satisfactorily prepared on this basis. As the survey progressed it became apparent that anomalies occurred under this method and the correlation between soil type and degree of salinity was less satisfactory than originally

thought. Thus the Camm sandy clay loam (1A), a heavy textured salmon gum type, proved generally saline in the early part of the work and in this respect contrasted with the lighter textured Camm sandy loam (1C) which was typically of low salinity. The survey being primarily to determine the incidence of soil salinity, for convenience in mapping the non-saline areas of the Camm sandy clay loam, as indicated by the field analyses, were included in the Camm sandy loam, and vice versa, when the anomalies were relatively infrequent. Later, however, saline and non-saline phases of the Camm sandy clay loam were recognised and mapped as such, thus correcting the errors with respect to soil type boundaries occurring under the original system of mapping. The same difficulty arose with the Milarup loam (4B) and in the later part of the work saline and non-saline phases were recognised. Reference to the field books would enable any necessary adjustments to the soil type boundaries to be made when the information is being prepared as part of the soil survey of Australia.

Three subdivisions with respect to degree of salinity were recognised.

(i) Low salinity.	First foot	— less than 0.10% salt*.
	Second foot	— less than 0.25% salt.
(ii) Medium salinity.	First foot	— 0.10 — 0.15% salt.
	Second foot	— 0.25 — 0.30% salt.
(iii) High salinity.	First foot	— more than 0.15% salt.
	Second foot	— more than 0.30% salt.

These limits were based on experience in the farming areas of Western Australia as well as on information derived from literature, particularly from the United States of America, and are still adopted as satisfactory standards for the judgment of soil salinity with respect to wheat growing in this State. Soils of the high salinity group under normal circumstances may be expected to yield about a half normal crop.

For convenience in presenting the data in map form, low salinity areas were coloured green, medium salinity areas brown, and high salinity areas yellow. Sand heath and wodjil types which were typically non-saline were left uncoloured on the maps. These colours were adopted to avoid confusion with the system of the Department of Lands and Surveys in which blue signifies first class and red second class.

In a recent paper, Teakle and Burvill (1938) have shown that such salinity data must be interpreted on the basis of soil type, and that soil types with a sandy surface which are saline in the virgin state rapidly lose their salinity after clearing. This finding was established as a result of later studies in the Salmon Gums area, and would enable some modification in the interpretation of the analytical data with respect to the Lakes District to be made. However, in the Lakes District there proved to be such a close positive correlation between the heaviness and salinity, and, in the case of morrel soils, between powderiness, or snuffiness, and salinity, that the application of this finding would not materially affect the conclusions with respect to the district.

The areas of each type and salinity grade as mapped on each farm were determined in the draughting room of the Department of Lands and Surveys by means of planimeters and the agricultural possibilities judged from the figures obtained.

* Throughout this paper the term "salt" means sodium chloride (NaCl) as estimated from chloride.

It is hoped that the data may be remapped on a scale of one inch equals one mile to bring this soil survey into line with others in the Commonwealth. At present the only maps available are hand coloured sun prints which are not suitable for publication but serve admirably for advisory and administrative purposes.

3. *Soil Classification.*

Some ten soil series of major importance were recognised in the course of the soil survey and have been named and registered with the International Society of Soil Science. In addition a number of types and variations of minor importance have been described and mapped on the large scale plans.

The soil types described are first listed in groups according to the vegetation association to afford a correlation between this soil survey and the land classification system of the Department of Lands and Surveys which is more familiar to farmers and others interested in agriculture. Following this list there is given a general description of the soil types grouped according to the soil series to which they belong, irrespective of the vegetation association. Brief mention is made of the chief physical and chemical properties which are given in detail in Tables A, B, C and D of the appendix.

In this discussion each soil type is given its series name and class description and, in order to associate these with the nomenclature used in the field survey and in the presentation of the results from the salinity viewpoint, the key numeral and letter, for example 1A, 5A, M8, etc., are also given.

The list of soil types described is as follows:—

(i.) *Soil types regarded as first class in the land classification system of the Department of Lands and Surveys.*

A. Soils of the salmon gum woodland.

(1)	Camm sandy clay loam (1A, 1AC)	13,275 acres.
(2)	Camm sandy loam (1C)	16,389 acres.
(3)	Pallarup sand (5B)	10,408 acres.
(4)	Pallarup sand, deep phase (5A)	1,938 acres.
(5)	Gulson sandy loam (1S)	490 acres.
	Miscellaneous minor types (1B and 1D)	381 acres.
	(8DS)	2,287 acres

B. Soils of the morrell and blackbutt woodlands.*

(6)	Milarup sandy loam (4A)	16,268 acres.
(7)	Milarup loam (4B, 2)	36,630 acres.
(8)	Milarup loam, hardpan phase (4L)	70 acres.
(9)	Milarup clay loam (9)	6,732 acres.

C. Soils of gimlet and merrit thickets.

(10)	Barookee clay (8B)	6,498 acres.
(11)	Varley clay (8D)	6,696 acres.

*In more recent classifications the Department of Lands and Surveys has not included these soil types in the first class group but has mapped them separately as morrel soils.

(ii.) *Soil types regarded as second class in the land classification system of the Department of Lands and Surveys.*

D. Soils of the mallee scrub.

(12)	Pallarup coarse sandy loam (M2, M5)	9,171 acres.
(13)	Pallarup coarse sandy loam, stunted mallee phase (M6)	1,354 acres.
(14)	Pallarup sandy loam, stunted mallee phase (M1)	5,594 acres.
(15)	Pallarup sand (M8)	24,488 acres.
(16)	Baanga sand (M4)	4,218 acres.
(17)	Varley gravelly sandy loam (M3)	1,158 acres.
(18)	Varley clay loam (M10)	165 acres.
(19)	Madden sand (G)	520 acres.
	Miscellaneous types (M7)	63 acres.

(iii.) *Third class soils in the land classification system of the Department of Lands and Surveys.*

E. Soils of the heath and wodjil plains.

(20)	Carmody sand (7)	36,521 acres.

F. Soils of the low-lying areas in depressions and adjacent to salinas which carry mallee and scrub.

(21)	Hurlstone sand (5C)	18,323 acres.

Summarised, the area surveyed may be classified as follows:—

(A)	Salmon gum woodland	45,168 acres.
(B)	Morrel woodland	59,700 acres.
(C)	Gimlet and merrit thickets	13,194 acres.
(D)	Mallee scrub	46,731 acres.
(E)	Heath and wodjil soils	36,521 acres.
(F)	Low-lying soils	18,323 acres.
		219,637 acres.
(G)	Small lakes and rock outcrops	9,030 acres.
	TOTAL ..	228,667 acres.

4. *Description of the Soil Types.*

The principal soils have been grouped into 10 soil series which comprise 20 soil types and phases. In a soil series the profile features, with the exception of the surface layer, are similar with respect to sequence and nature of the layers, and also the nature of the parent material. Thus the sequence of the profile colours as observed on the face of the pit will be substantially the same, as also will be the clayeyness or sandyness of the various layers. Each series is given a name, usually taken from a locality in which it occurs, in order to facilitate its definition. A soil type is a subdivision of a series on the basis of the texture of the surface layer and is designated by the series name and a class name which is the texture of the surface horizon.

In some instances, soil types have been further subdivided into phases on the basis of major variations in vegetation cover and such factors. It might be argued that more series should have been recognised to cover such factors. For instance, it may be reasonable to assume that, in general, the nature of the vegetation association—the growth of salmon gum instead of mallee, or the height and vigour of the mallee scrub—reflects soil characters of considerable agricultural significance but which are difficult, or perhaps impossible, to observe by field inspection of the profile. But this would limit the soil surveyor to complete recognition of soil types only in virgin country, and, further, such an assumption completely overlooks the established fact of succession of vegetation associations and the effect of fires and similar factors on the plant cover.

In addition to the principal types, a number of soils of minor agricultural importance have been grouped as miscellaneous soils and described for the purpose of completeness.

(i) *The Camm Series.*

The Camm series, named after Lake Camm, is the heaviest type of the area associated with the salmon gum woodland. The principal features of the profile are a brown to brownish grey surface of loamy sand or sandy loam not more than 6in. deep, resting on a brown to greenish brown sandy clay subsoil with lime accumulation becoming marked from about 8in. or deeper. With the lime accumulation, whitish and grey colours become important in a mottled subsoil (see Fig. 3).

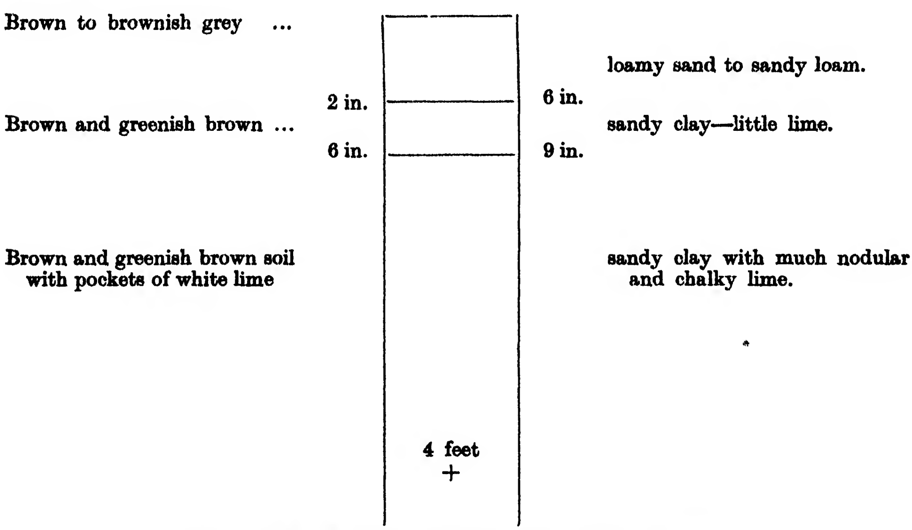

Fig. 3.—Features of the profile of the Camm series.

The series is probably developed on granitic or gneissic rock material.

Proceeding from south to north, there is a gradual change in the colour of the soil; grey shades are more obvious in the south and the browns in the north.

The vegetation association may be described as a sclerophyll woodland in which salmon gum, gimlet, boree and mallee scrub are the chief of the larger plants. Other species are merrit, hop, daisy, centipede bush, clay bush, quondong, *Eremophila pachyphylla, E. glabra,* rushes, *Danthonia, etc.*

Chemically, the soils of this series are low in phosphate but are rich in lime, potash and magnesia.

For general agricultural purposes this series is undoubtedly the best of the district. Unfortunately, however, the heavier type is often saline but observations at Salmon Gums indicate that it may improve under appropriate management for pasture production and grazing.

The series is divided into two types on the basis of the depth of the surface sandy loam horizon.

Camm sandy clay loam (1A, 1AC).

In the Camm sandy clay loam the A horizon is limited to 2 - 3in. of sandy loam and rests on a sandy clay subsoil in which the lime accumulation commences at a depth of 6 - 9in. It is designated a sandy clay loam as, when ploughed, the admixture of the clay subsoil with the sandy loam surface will give rise to a soil which will behave agriculturally as a heavy type. The soil is commonly characterised by gilgai or crabholes. These are undesirable agriculturally as they interfere somewhat with cultivation. Furthermore, the heaviness of the soil is undesirable under low rainfall conditions and crops will be subject to drought effects when the rainfall is below average. Associated with the heaviness is a concentration of soluble salts in the profile to an undesirable degree. Analyses of samples from 717 sites averaged 0.18% salt in the first foot and 0.35% salt in the second foot. This concentration of soluble salts will increase the liability of crops to suffer during drought periods and would lower substantially the general crop yields of sensitive crops such as wheat. The type should be very well suited for Wimmera rye grass establishment which will be a valuable basis for stock raising as an adjunct to wheat growing.

Camm sandy loam. (1C.)

The surface or A horizon of the Camm sandy loam consists of from three to six inches of sandy loam. Crabhole development is uncommon, but in other features the type closely resembles the sandy clay loam. The vegetation is also very similar but includes such plants as rosemary and *Restionaceae* which are indicative of more sandy conditions. Salinity is typically low in this type. Samples from 817 types averaged first foot 0.06% salt, second foot 0.17% salt.

It is considered that this type is the most suitable in the district for general agricultural purposes.

(ii) *The Gulson Series.*

Gulson sandy loam. (1S).

Only one soil type was recognised in this series and has been described as the Gulson sandy loam. The profile consists of a red brown sandy loam surface, somewhat powdery in nature to a depth of about one foot, on a brown light clay with small calcareous nodules. Below two feet the colour lightens to light brown, and both chalky and nodular limestone have accumulated. (See Fig 4).

The vegetation cover is an open woodland of salmon gum with an undergrowth chiefly of salt bush with scattered daisy, quondong and clay bush. Analysis of 28 sites representing this site showed it to be generally non-saline. It should be quite suitable for general agricultural purposes.

Red brown	12 in.	sandy loam.
Brown	24 in.	light clay with small calcareous nodules.
Pale brown	4 feet +	clay with chalky and nodular lime.

Fig. 4.—Features of the profile of the Gulson series.

(iii.) *The Milarup Series.*

A range of grey brown to dark brownish grey highly calcareous soils of loose, powdery structure when dry, and which are typically associated with a morrel and boree woodland, is included in the Milarup series. The surface layer of the soil is darkened by humus enrichment and is rich in calcium carbonate. In this latter respect it varies from the usual normal soils of the zone as the calcium carbonate is characteristically confined to the subsoil or B horizon. Frequently the surface quarter of an inch has a somewhat platy or crusty structure due, apparently, to the growth of small organisms in a rich soil medium. Representative profile features are illustrated in figure 5.

Brownish grey to dark grey	6 in.		9 in.	sandy loam to clay loam—very powdery when dry.
Very pale brown	18 in.		24 in.	loam to clay with calcareous nodules.
Light brown, buff to pinkish fawn		4 feet +		clay loam to light clay with calcareous nodules.

Fig. 5.—Features of the profile of the Milarup series.

The surface is brownish grey to dark grey in colour and ranges in texture from sandy loam to soft clay loam. It is commonly from 6-9 inches deep and in the virgin woodland is usually bounded by a mass of roots and rootlets. The powdery condition when dry is one of the most important features and appears to render it unsatisfactory for ordinary cereal crops until thorough compaction occurs. Whether the content of calcium carbonate is responsible for this powdery condition has not yet been determined. Below the surface horizon is an intermediate layer of light brown to very pale brown soft clay loam rich in lime in the fine earth, and often with a few calcareous nodules. Below this again is a highly calcareous subsoil which ranges from clay loam to soft clay in texture, and in colour from light brown, grey brown, and buff to pinkish fawn. This subsoil is typically rich in limestone nodules, usually loosely embedded in a loose soil mass. In some instances the limestone nodules may be cemented to form a dense hardpan. With depth, clay accumulation occurs and the subsoil becomes more compacted, particularly in the heavier types.

The series carries a characteristic vegetation association. The chief elements are red and black morrel, forbor, boree and merrit. Kondinin blackbutt is characteristic of the heavier textured types near the lakes. Of the undergrowth the commonest species are navy bush, daisy, hop, salt bushes, *Kochia spp.*, *Eremophila glabra* and *E. pachyphylla.*

Chemically the soils of the Milarup series are the richest in plant mineral requirements. While the phosphate is low, it is somewhat higher than in the other soil series and, in addition, shows a substantial accumulation in the surface or A horizon. It is rich in potash throughout the profile, most of the samples containing more than 1% potash (K_2O). The soil is particularly rich in lime; even the surface horizon generally contains from 5-10% calcium carbonate, while the subsoil may contain up to 40% calcium carbonate in the fine earth fraction. In addition to this, there is a considerabe amount of lime in the form of calcareous nodules which are not included in the analyses reported in Table C of the appendix.

With the exception of the Milarup sandy loam, the soils of this series are generally unsatisfactory for wheat growing, except in years of generous rainfall. When the rainfall is adequate apparently the wheat crop is able to take advantage of the generous supply of plant mineral requirements, but, apparently due to the physical condition, crop growth suffers during the spring months in dry seasons. The soils of the series generally have a value for pasture production, and barley grass, Wimmera rye grass and salt bushes are the most promising species. Liability to salt accumulation, particularly in certain types, further limits the value for agricultural purposes.

The series has been sub-divided into three types and one phase.

Milarup sandy loam. (4A).

The profile characteristics of this type are a brown to grey sandy loam surface, generally calcareous and somewhat powdery when dry, and a clay or sandy clay subsoil which is usually firmer than in the case of the more typical Milarup loam.

The type is frequently transitional between the Milarup loam and types of the salmon gum woodland, and is very variable on that account. In some cases areas which include a pattern both of the salmon gum woodland types and the Milarup series have been mapped as the Milarup sandy loam.

Generally, the type is relatively low in salinity; samples from 919 sites averaged 0.05% salt in the first foot and 0.14% salt in the second foot. Agriculturally the type is reasonably suitable for general farming, including both wheat and pasture production.

Milarup loam. (4B, 4BA, 2).

Of all the so-called snuffy morrel soils recognised by agriculturists in Western Australia, the Milarup loam is probably the most snuffy or floury. When dry, the surface material will frequently flow like silt, will not readily absorb water, and will take an impress in considerable detail; for instance, the finger prints and lining on the hand can be clearly impressed on a pile of the fine, dry surface soil. Naturally a soil of this nature is difficult to compact should it be ploughed deeply in the course of cultivation, and is very liable to wind erosion under fallow conditions. Experience shows this snuffy condition to be undesirable agriculturally as satisfactory wheat crops are unusual except in wet seasons.

The surface soil is highly calcareous but the percentage of calcium carbonate in the profile increases with depth showing accumulation in the subsoil or B horizon. In the subsoil the calcium carbonate occurs both as nodules and in a floury or marly condition in the fine earth fraction. In some instances the calcareous nodules comprise as much as 50 per cent. of the soil mass.

Although the Milarup loam is the richest soil of the district from the chemical viewpoint, in the early years of development the type will be more suited to pasture production than to wheat growing. When cultivated, only a shallow surface working should be used and the use of stock and compacting implements is advised to bring about an improvement in the structure of the soil. In the course of years these methods bring the soil to a more satisfactory condition and the type will produce fairly satisfactory crops when the season is suitable. However, the type must be regarded as one of the most difficult of all the eucalyptus woodland soils to manage for arable agriculture.

Coupled with these disabilities is a high liability to salinity. The structure of the soil appears to limit moisture penetration and favours capillary rise even when only in the moist state, and no water table is within many feet of the surface. In consequence, under cultivation, the Milarup loam is very commonly affected by infertile salt encrusted patches (see Teakle and Burvill (1938) pp. 224-225), which seriously reduce productivity. The average salinity of samples from 1,739 sites, principally in virgin country, was: first foot 0.19% salt, second foot 0.37% salt.

The principal elements of the vegetation have been listed above. A characteristic species which warrants further mention is a type of boree which has been designated forbor (*Melaleuca quadrifaria*). This has been found to be a useful indicator of salinity and an undesirable snuffy condition.

Milarup loam-hardpan phase (4L).

This phase is characterised by a hardpan or cement of travertine (calcium carbonate) which occurs at a depth of about one foot. It is characteristically low in salinity. However, it is of low agricultural value on account of the snuffy condition of the surface when dry and the shallow depth of the useful soil.

Milarup clay loam. (9).

The Milarup clay loam exhibits many of the general features of the loam type described above but is less snuffy and somewhat heavier throughout the profile. It generally occurs in closer proximity to the salt lakes and is characterised by a rather open stand of Kondinin blackbutt, a thick ground cover of salt bush and scattered clumps of forbor. Box thorn and grey bush are common species of minor intensity.

The profile typically consists of about six inches of heavy loam or clay loam, dark grey in colour, with a subsoil of brownish grey to grey brown clay loam or light clay to a depth of three feet. Below this depth the subsoil is browner in colour and more clayey in texture, but a dense clay is not encountered until a depth of several feet is reached. The profile is calcareous from the surface to a depth of nine to ten feet, but calcareous nodules are far less common in the subsoil than in other types of the series. There is evidence that the profile is acidic and non-calcareous below ten feet.

The soil is generally highly saline. Samples from 302 sites, largely in virgin country, averaged: first foot 0.30% salt and second foot 0.59% salt. The type is of low value for cropping purposes where saline but has a value for stock raising on account of the salt bush. It will probably carry a variety of grasses when partly cleared and fertilised. As is the case with other types of the series, the fertility status with respect to plant mineral requirements, except phosphate, is good, and with judicious grazing the type should be of considerable value for stock raising.

(iv.) *The Varley Series.*

Strips and patches of heavy soils, reddish to brown in colour, occur on the rising ground intermixed with the lighter soil types. These appear to be formed on rock exposures probably of different mineral composition from the main mass of the country rock, and, from the point of view of vegetation cover, are characterised by gimlet, frequently in the form of whipstick thickets. The series should be quite good agriculturally but on account of the heavy texture will probably suffer from drought in low rainfall seasons. Three types have been recognised:—

Varley Clay (8D).

The profile is relatively simple and typically shows a surface layer of red brown clay to a depth of about one foot, with a subsoil of light brown calcareous clay. The surface is frequently strewn with quartz and ferruginous gravel and generally breaks into cracks during the dry summer period. Crabholes sometimes occur.

Whipstick gimlet is the typical vegetation and associated with it are merrit, hop, and a variety of teatrees, including umbrella bush. Curiously enough, in spite of the heavy texture, this soil is characteristically non-saline. The average salt content from 438 sites was: first foot 0.06% salt, and second foot 0.16% salt.

Varley Gravelly Sandy Loam (M3).

Included in the Varley series is a small area, 1,158 acres, of stunted mallee country which occurs as strips between the sandplain and the timber country. The profile consists of a few inches of brown to red brown gravelly sandy loam on a

brown subsoil in which the clay content increases until a heavy clay horizon is encountered in the second foot. This clay subsoil is frequently mottled with red patches, apparently of decomposing laterite.

The chief species associated include a number of mallees, a sprinkling of gimlet, native cherry, and a variety of teatrees. In the virgin state the soil is typically saline, samples from 61 sites averaging 0.23% salt in the first foot and 0.41% salt in the second foot.

Varley Clay Loam (M10).

A small area of soil in which the profile consists of a red clay loam on a red clay subsoil has been included in the Varley series on account of the similar profile features. The vegetation is principally stunted mallee scrub which may represent a succession from some more robust vegetation in previous years. It resembles the Varley clay in being relatively low in salinity. Samples from five sites representing the type averaged 0.11% salt in the first foot and 0.26% salt in the second foot.

(v.) *The Barookee Series.*

Barookee Clay (8B).

A soil type, related closely in many ways to the Varley clay, but differing in colour, structure, and vegetation association, has been named the Barookee clay. Like the Varley clay, this type occurs generally in strips in lighter country and probably is the result of exposure of different rock types. The surface horizon consists of about nine inches of heavy clay loam or light clay, which is somewhat powdery when dry and brown to light brown in colour. The upper subsoil to a depth of about three feet is a pale brown, highly calcareous clay, the calcium carbonate being generally of a chalky nature. A little mottling of red iron stains sometimes occurs. Below three feet is a somewhat uniform brown clay, relatively low in lime.

The vegetation is typically a thick growth of merrit often associated with a little gimlet and occasional salmon gum. A dense undergrowth largely of umbrella bush, *Acacia spp.*, needle bush, with some native cherry, boronia and hop is characteristic.

Unlike the Varley clay this type is highly saline. Three hundred and seventy-eight sites representing the series gave an average salinity of 0.22% salt in the surface foot and 0.42% salt in the second. On account of the salinity it is unlikely that this type will be of much value for wheat-growing, but where it has been cleared in association with other more satisfactory types, it will probably have some value, particularly for pastures. While the type is rich in potash, it is particularly low in phosphate so that little growth of valuable pastures can be expected without the use of superphosphate. The high sodium content of the replaceable metallic cation fraction in the surface soil is another undesirable feature. (Table D of the appendix.)

(vi.) *The Pallarup Series.*

In this series has been placed a number of soil types which, while undoubtedly closely related, may, on closer examination, be classified in different series. In the absence of this necessary information it has been deemed advisable to associate these related types on the understanding that sub-division into additional series may be advisable in the future. For the present the relationship of these

types is emphasised, but the descriptions include all of the information at present available regarding each soil type or phase, and each can well be considered as a unit. Thus from the agricultural viewpoint it may be desirable to consider the timber phase of the Pallarup sand (5B) as distinct from the mallee scrub phase (M8), but definition as separate series is undesirable in view of the inadequacy of the field and laboratory data at present available.

The essential features of the Pallarup series are a surface sandy layer which ranges in depth from two to three inches in the case of the heavier types to as much as two feet in some of the more sandy types, and a subsoil of sandy clay loam to sandy clay. Cementation of the surface of the subsoil results in a sharp break between the sandy "A" horizon and the clayey "B" horizon. The surface colours range from brown to brownish greys on the surface and, where the sand is deep, these shade off to pale brown, grey or even white in the subsurface. In the subsoil the predominant colours are greenish browns and greenish greys. Calcium carbonate, partly in the form of hard nodules, accumulates in the subsoil. The commencing depths for calcium carbonate accumulation range from about eight to 20 inches, depending on the thickness of the surface sand. The upper part of the subsoil (B_1 horizon) is typically only very slightly calcareous. (See Fig. 6.)

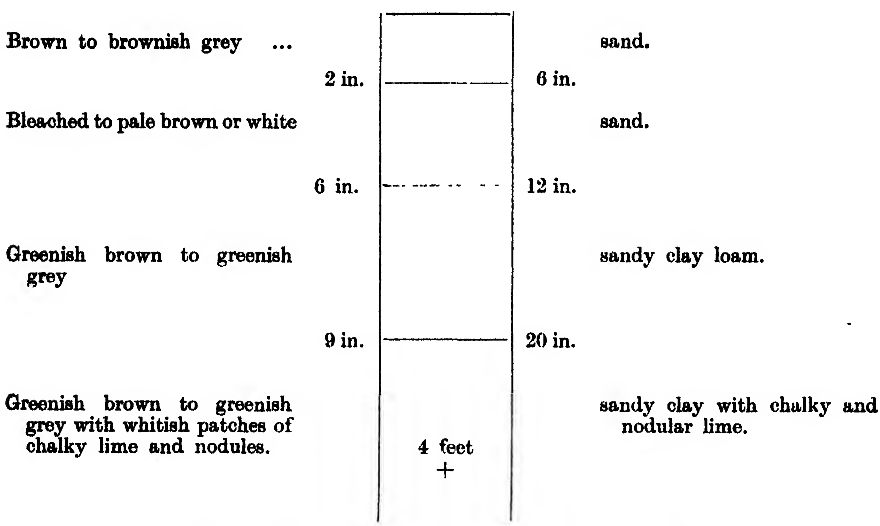

Fig. 6.—Features of the profile of the Pallarup series.

According to the feel in the field, the surface sand varies from relatively fine to relatively coarse. From the absence of confirmatory data from the results of mechanical analyses it seems probable that this variation is due to differences in grain size distribution within the coarse sand fraction (0.2 to 2.0 mm. diameter). No sieving data are available. This variation, as recognised in the field, has been used to separate soil types in mapping, as it is suspected that this property of the sand fraction is indicative of more fundamental variations in the parent material. Further information is required to establish this point but is not obtainable under present conditions.

The soils of the series are very low in phosphate, potash is relatively low in the surface but generally exceeds 1% in the subsoil. With the use of superphosphate the fertility status of this soil should be readily maintained, and, as the

lightness of the surface layer promotes water absorption and moisture retention, these types, where the depth of the sand is not excessive, are of considerable value for agriculture under low rainfall conditions. Under fallow conditions the soil is liable to wind erosion, which would seriously reduce the agricultural value if the surface were completely removed and the subsoil exposed. The chemical properties of the subsoil clay render it undesirable for cultivation so that every effort should be made to preserve the natural surface to maintain the cropping value of the soils.

The vegetation is typically a mallee scrub, generally more or less stunted, with an undergrowth of needle bush, blue tea-tree, rosemary, *Hibbertia sp.*, *Restionaceae*, etc. Areas of similar profile characteristics which carry salmon gum have been recognised as a phase.

The Pallarup series of the Lakes District and the Circle Valley series of the Salmon Gums district are very similar in general properties. They undoubtedly belong to the same fasc or group of soil types, but sufficient work has not yet been done to decide their precise relationships and for that reason they are described as different series. It is known that they are very closely related chemically, but further work with respect to other properties would be needed before the soils were included in the one soil series.

Pallarup Sandy Loam (M1).

The profile consists of 2 to 3 inches of light brown sand on a greenish brown to greenish yellow sandy clay loam subsoil. Below about 9 inches calcium carbonate, largely as rubble, accumulates and a calcareous clay subsoil extends to a depth of several feet.

An open, low mallee scrub, 6 to 8 feet high, is the characteristic vegetation; low tea-trees, *Acacia spp.*, needle bush, boronia, daisy, etc., comprise the undergrowth.

In the virgin state, the soil is frequently moderately saline, the average of all samples representing the type being 0.12% salt in the first foot and 0.30% salt in the second foot. Following clearing a certain amount of leaching should occur, with the result that salinity should not materially affect crop growth in this soil type.

Pallarup Coarse Sandy Loam (M2 and M5).

The profile consists of 2 to 3 inches of light brown coarse sand on a yellow brown sandy clay loam to sandy clay subsoil in which limestone rubble accumulation commences at about 9 inches. The vegetation is a well grown mallee scrub, 12 to 15 feet in height, which, together with the coarseness of the sandy surface, differentiates it from the Pallarup sandy loam described above. The ground cover consists largely of tea-trees and shrubs.

The soil survey showed that, while the salinity is generally high in the southern areas, a considerable proportion of the type is relatively low in salt in the northern part of the district. The more saline phase has been mapped as M5 on the working plans and the non-saline phase as M2. Analyses of samples representing these phases are as follow:

Depth (feet)	M5 (saline phase) 265 sites.	M2 (non-saline phase) 214 sites.
First foot	0.21% salt	0.05% salt
Second foot	0.39% salt	0.15% salt

From subsequent experience in the Salmon Gums district it appears that the occurrence of salt in the Pallarup coarse sandy loam should not seriously interfere in crop returns, on account of the degree of improvement after clearing, but some reduction in yield must be expected on this account. The soil type can be regarded as good class mallee land where the salinity status is low in the virgin state, and can be given a fairly satisfactory rating even where the salinity in the virgin state proved high.

Pallarup Gravelly Sand (*M*6).

The Pallarup gravelly sand is a type largely confined to the southern portion of the area where higher rainfall occurs and some degree of impeded drainage in the winter appears to be a factor in its development. The profile consists of a few inches of light brown to grey brown coarse sand with some ferruginous gravel on a brown sandy clay subsoil. In the second foot the subsoil is a greenish brown sandy clay with limestone rubble.

The vegetation is characteristic and consists largely of stunted mallees, chiefly swamp gimlet, stunted blue teatree and umbrella bush, and a variety of shrubs.

The type proved highly saline, samples from 58 sites averaging 0.25% salt in the first foot and 0.49% salt in the second foot. On account of the nature of the profile and the salinity, it is likely to be of inferior agricultural value.

Pallarup Sand.

A number of mallee and timber phases in which the profile characters are essentially similar have been included in the Pallarup sand. Further information may enable separation to be made of some of these phases into distinct series. It is the most extensive mallee scrub type of the district, and important areas of salmon gum woodland have been mapped as a woodland phase of the type.

The surface or "A" horizon consists of from six to 12 inches of sand, relatively fine to the feel, and grey brown to brownish grey in colour on the surface. The lower part of the sand layer is typically bleached and in the lighter mallee scrub types is reduced to a white colour. The subsoil is a greenish brown to greenish grey calcareous sandy clay loam or sandy clay with much calcareous rubble below about 15 to 20 inches. When dry, the subsoil cements to a very hard layer, particularly at the surface of the clay in contact with the sandy surface ("A" horizon).

Pallarup Sand-mallee Scrub Phase (M8).

The vegetation is principally mallee scrub of medium height (10 to 12 feet) with blue teatree associated with other shrubs as the principal undergrowth. The salinity is generally low in the virgin state and, on account of the rapid leaching of salt after clearing, soil salinity will not be an agricultural problem on this type. The type is of only medium fertility on account of the depth of the surface sand, but should be satisfactory for general agriculture, particularly in low rainfall areas. Special attention should be given to the control of wind erosion in the management programme.

Pallarup Sand-woodland Phase (5B).

Where salmon gum woodland occurs on the Pallarup sand the soil is generally browner in colour, and the high degree of bleaching common in the subsurface layer of the mallee scrub phase is typically absent. It is probably of somewhat higher fertility status, although the profile features are essentially the same.

On this phase the vegetation includes salmon gum, redwood, yorrel, a variety of mallees and an undergrowth principally of daisy, rosemary and *Restionaceae.* The significance of the difference in vegetation cover is not understood.

The salinity is typically low, samples from 460 sites averaging only 0.05% salt in the first foot and 0.14% salt in the second foot. The phase is regarded as of very considerable agricultural value, but like the mallee phase, it should be carefully managed on account of liability to wind erosion.

Included with this phase of the Pallarup sand is a sub-type, mapped as 5A in the field, in which the surface sand is from one to several feet deep, but in which the subsoil appears to be more or less typical. This sub-type covers only a small area (1,938 acres) and is largely confined to large dune-like rises on the east side of the salt lakes. Sand salmon gum commonly replaces salmon gum, but the vegetation is otherwise similar. More psamophilous shrubs are common.

(vii.) *Baanga Sand* (M4).

A low fertility sandy soil in which the profile consists of at least a foot of grey brown to light brown sand on a reddish brown sandy clay subsoil with some calcareous rubble. In the virgin state vegetation is principally stunted mallees and low broom bush, with a variety of *Restionaceae* and small shrubs on the undergrowth. It is a low fertility type, generally occurring adjacent to the Carmody series with which it has probable relationships. It is typically non-saline.

(viii.) *The Carmody Series.*

Included in the Carmody series is a group of sandy and gravelly (ferruginous) soils of the heath plains commonly known as sandplain. Common profile features are a surface of about six inches of brownish grey sand, often with a yellowish tinge, on a brownish yellow loamy sand subsoil with loose ferruginous gravel. The gravel typically increases with depth to reach approximately one half of the soil mass. Below the loose gravel and sand layers is a cemented whitish sandy material with some decomposing ferruginous inclusions.

The soils of the heath plains range from deep sands to highly gravelly types. They are of low fertility, rather acidic in reaction, and calcium carbonate does not appear to accumulate, even in the deeper parts of the subsoil. They are low in all of the usual plant mineral requirements. However, where a certain amount of clay accumulation occurs in the subsoil, these types may be useful agricultural soils and, with generous use of superphosphate, generally yield satisfactory cereal crops in the years of lower rainfall.

In the southern portion of the area, strips of brown clayey soil occur in the sandy heath types. The subsoil is calcareous and the profile resembles types of the mallee scrub rather than of the heath vegetation associations. However, the natural vegetation is limited to sparse low shrubs and scattered stunted mallees. This type was not mapped but included in the areas classified as the Carmody series.

(ix) *Hurlstone Sand* (5C).

This type embraces the sandy surfaced soils of depressions and low lying areas adjacent to the salt lakes.

Throughout the area, particularly in the vicinity of the salt lakes in sandy formations, are patches of sandy surfaced soils which resemble the Pallarup sand in general profile features. These soils have developed in low-lying areas and

depressions and carry a vegetation association which is commonly described as lakey, as indicative of lakey conditions and the probable proximity of a salt water table.

Typical species include swamp gimlet, *Eucalyptus annulata,* yorrel, odd Kondinin blackbutt, *Melaleuca thuyoides,* borees, paper bark, teatrees, etc.

As in the profile of the Pallarup sand, the surface of the Hurlstone sand consists of from six inches to one foot of sand which is grey brown to light brown in colour on the surface and whitish in the subsurface layers. The subsoil is a brownish to greenish sandy clay. Lime accumulation occurs with depth, and from 18 to 20 inches calcareous rubble embedded in the clay is common. An interesting feature is the green colour which is apparent in newly exposed subsoils throughout this type. This seems to be due to reducing action following waterlogging of the surface sand during periods of wet weather.

The Hurlstone sand is very variable in salinity. The average for 409 sites gave a concentration of 0.14 per cent. salt in the first foot and 0.30 per cent salt in the second foot. This would place the type in the medium salinity group, but in mapping it has been regarded as potentially saline, because experience in other districts shows that a high degree of salinity is liable to develop due to a rise in the salt water table in the course of a period of years. Development of the surrounding country leads to a general rise in the water table and this has the effect of raising the salt water table in the low-lying areas to such an extent that surface evaporation becomes possible and salt accumulation is observed on the surface of the soil, rendering the land virtually useless for agriculture. In the initial stages of development, salinity does not show on this soil type and the immediate result of clearing would be a leaching of the salt into the deeper layers of the subsoil as in the Pallarup sand and related types. It was felt, however, that this type should be mapped as one potentially liable to serious damage from salinity, so that farmers would be warned as to possible future developments.

(x) *Madden Sand* (G).

Around the granite outcrops occur shallow brown sandy and sandy loam soils apparently formed from the granite rock material which occurs a foot or so below the surface. These soils in the virgin state carry a vegetation principally of York gum mallee and jam, with a variety of shrubs, of which a type of hop (*Dodonea larraeoides*) is typical.

(xi) *Miscellaneaus Soil Types.*

Sub-type 1*B*.

Heavy gimlet flats where the soil consists of a few inches of brown loam on a light brown heavy clay subsoil were classified as sub-type 1B. This soil appears to be of reasonable fertility, but is low-lying, liable to inundation and is not regarded as of high agricultural value. It is of little importance as it covers an area of only 347 acres in the district surveyed.

Sub-type 1*D*.

A soil type of low-lying areas which carries some gimlet and scattered salmon gum. The profile consists of a shallow surface of grey gritty sandy loam on a greenish brown sandy clay subsoil. It is highly saline and is regarded as of little agricultural value.

Sub-type 8DS.

A range of apparently related soil types, characterised by a brown sandy clay loam surface and a variable subsoil, has been mapped as 8DS. It appears to be related to the Varley clay in many respects and is apparently formed where basic rocks occur in relatively large patches, commonly where the topography is distinctly hilly. The chief profile features are a brown to red brown sandy clay loam surface, with a certain amount of ferruginous and other gravel, resting on a brown sandy clay subsoil, usually rich in calcareous rubble. In some instances, soils with a pale brownish green subsoil, rich in calcareous rubble, have been included in the type.

The typical vegetation is a woodland of salmon gum and gimlet with a variety of shrubs comprising the ground cover. The salinity is low, the average from 124 sites being 0.06% salt in the first foot and 0.17% salt in the second foot. The type should be of good agricultural value.

Sub-type M7.

Small patches of soil resembling the Milarup series in certain profile features, but which carry a stunted vegetation of mallee scrub, have been mapped as sub-type M7. These patches are of very little agricultural significance.

V.—DISCUSSION.

The soils of the Lakes District may be discussed under four headings:

1. The general fertility status.
2. Chemical and physical properties.
3. The salinity problem.
4. Agriculture.

1.—*General Fertility Status.*

In accordance with the policy of the Department of Lands and Surveys with respect to land classification, lands of the agricultural areas to the extent of 53,000,000 acres have been grouped into first, second and third classes. These classes are essentially indices of estimated land values for agricultural purposes, and have proved to be extremely useful in land settlement. In the wheatbelt, these classes correspond very closely to the main vegetation types.

The first class land typically carries woodlands of salmon gum, York gum, gimlet, morrel, etc. The second class land typically carries mallee scrub, scrubby jam, etc., and the third class lands are the heath and wodjil plains where the soils are sandy or gravelly in character.

Experience has shown that the vegetation cover is a reasonably reliable guide to the productive capacity of the soil. However, as land settlement extended to the lower rainfall areas such as Lake Brown, Salmon Gums and the Lakes' District, serious anomalies were experienced in the application of this method of classification. The snuffy soils of the morrel woodlands proved unsatisfactory for wheat growing, particularly in Lake Brown and other areas in the Merredin and Fitzgerald regions (Teakle, 1938). Soil salinity interfered somewhat at Lake Brown and to a considerable degree at Salmon Gums. In the Lakes District, snuffy soils of the morrel woodland and saline soils combined to render the old method of classification difficult to apply. In this survey the anomalies have been substantially corrected by recognition and mapping of the principal causative factors, and it has been established that, apart from the incidence of anomalies due

to the characters of the morrel woodland soils and salinity, it can be assumed that generally the woodland types are of first class grade and are of normal productive capacity. Soil types of the mallee scrub are intermediate and the sand heath and wodjil types are of least productive capacity.

Of course, the better class mallee scrub soils such as the Pallarup coarse sandy loam, may be superior to the inferior woodland types and good class heath land may be quite productive in suitable seasons, but the generalisation holds and the success of the district will largely depend on the utilisation of the suitable woodland and better class mallee scrub soils. Deeper sandy types, while reasonably productive if suitably managed, have not the mineral resources in the surface layers and will be liable to erosion and impoverishment if over-stocked.

2.—*Chemical and Physical Properties.*

Chemically, the woodland and better class mallee scrub soils of the Lakes District are as sound with respect to the main mineral requirements for plant growth as in any part of the same soil zone in Australia. There is no doubt that the feeding quality of the pasture produced is high and, apart from areas affected by excessive salinity and the difficulties associated with the snuffy morrel group, the cropping capacity of these soils should be satisfactory. Excepting the Carmody series, which is representative of the heath and wodjil plains, examination of the analytical results (see Appendix A) shows that for the soils of the district the lime, magnesia and potash status is very high, particularly in the subsoil, and these qualities probably reflect an abundance of many other important soil minerals. Phosphate is deplorably low. The soils of the Milarup series, in which some surface accumulation of phosphate has occurred, suffer from other disabilities. Fortunately, phosphate can be cheaply supplied as superphosphate and effectively overcomes the deficiency. The reaction of these soils is typically alkaline, particularly in the subsoil, but is not excessively so.

In common with all dry land soils, total nitrogen and organic matter are low but apparently adequate for ordinary farm practice under wheatbelt conditions. In comparison with soils of more developed areas where the carbon : nitrogen ratio tends to approach 10, for these soils the ratio is fairly wide, particularly in the surface. In this property these soils are related to those of the "mallee" areas of South Australia (Prescott and Piper, 1932). Furthermore, the ratio is wider in the surface layers than in the subsoil and is wider in the case of the light Pallarup soils than in the Camm and Milarup types. These facts indicate that the carbonaceous fraction of the leaves, bark, etc., added annually is not decomposed with sufficient rapidity, in comparison with the loss of the nitrogenous fraction, for the formation of soil organic matter with a carbon : nitrogen ratio approaching 10. While this is probably largely the result of climatic conditions, the wider ratio of the Pallarup series, as compared with the Camm and Milarup series, indicates that the mineral status of the soils is also of importance.

Of considerable interest is the composition of the replaceable cations, those labile minerals of the clay and organic matter. In alkaline soils, the chief constituents of this fraction are calcium, magnesium, potassium and sodium, and a knowledge of the ratio of these minerals gives an important clue to the history and nature of the soil and indicates probable reactions under farming practice. This information also assists in grouping the soils into zones recognised elsewhere.

In general, the composition of the replaceable cation fraction of the soils of the Lakes District compares closely with that of South Australian soils of the mallee zone described by Prescott and Piper (1932). The surface or "A" horizon

is of normal composition, the dominant replaceable cation being calcium, but sodium is higher than for soils regarded as normal according to European and American standards. In the subsoil, the calcium of the fraction is largely replaced by sodium, the degree of replacement increasing with depth in the profile. This process of replacement of calcium by sodium is known as solonisation, and it is thought that, in this instance, it is due to age-long treatment with rain water which, in this district, carries down from 20 to 30 lbs. of sea salt per acre per annum. Under these low rainfall conditions a very large proportion of the moisture absorbed from the rainfall is dissipated by the vegetation, the salt accumulates in the subsoil and, in consequence, the sodium enters the soil as a replaceable cation. Calcium accumulates largely in the form of calcium carbonate.

The high calcium status of the surface layers is evidently due to the leaching effect of the rain water in the immediate surface layer or zone of leaching. Laboratory studies carried out by Kelley (1937) in California have demonstrated that leaching with pure water will bring about this accumulation of replaceable calcium even on soils originally rich in sodium.

In common with soils throughout Australia magnesium constitutes a large proportion of the replaceable metallic cation fraction. As replaceable magnesium is high in soils under a wide variety of conditions, it is thought that the process of solonisation has probably not contributed to the magnesium concentration in this instance.

It has been well established that soils of most desirable physical properties and most suitable for agricultural development are those in which calcium is high in the replaceable cation fraction. For this reason it is unfortunate that the surface layers of these soils are of the calcium-magnesium type. But the subsoils are of the sodium-magnesium type with respect to replaceable cations. Sodium clays usually exhibit undesirable physical properties. They readily lose their structure. They are sticky when wet and readily puddle when cultivated so that they come intractable to work with agricultural implements. For this reason it is imperative that the surface soils in the Lakes district be protected as far as possible against loss. Erosive forces must be strictly controlled and cultivation should not be so deep that the subsoil clays, rich in sodium and with undesirable physical properties, are brought to the surface. Subsoil farming on these soils will be difficult and unprofitable, not only on account of the undesirable physical qualities under cultivation, but also because such soils provide an unsuitable medium for the proper development of crop roots.

Another point of interest with respect to the chemical nature of these soils is the concentration of calcium carbonate in the surface of the Milarup and Barookee series. Normally, as in the Camm and Pallarup soil series, calcium carbonate accumulates in the clay subsoil in what is technically known as the B_2 horizon. In the Milarup and Barookee series, however, the surface layer contains several per cent. of calcium carbonate. It is thought that the presence of calcium carbonate in the surface layers is due to the cycle of minerals brought about by the action of the vegetation. From field observations it is thought that the vegetation associations occurring on these soil types deposit calcium in their leaves, bark and other debris faster than it is removed by the leaching action of the rain. Consequently, the surface, as well as the subsoil, is calcareous. In the other soil types, under a different vegetation association, the deposition of calcium is at a slower rate than the loss from the surface as a result of leaching by the rain water, so that accumulation is confined to the subsoil.

Details of the chemical data are given in the tables A, B, C, and D in the appendix. These are summarised in Table 2.

TABLE 2.

Distribution Table showing Mineral Status of the Woodland and Mallee Scrub Soils of the Lakes District. The numbers show the Percentage in each range of the number of samples examined.

PHOSPHATE (P_2O_5) PER CENT.

Range	Below ·005.	·005–·01.	·01–·02.	·02–·04	·04–·06.	·06–·08.	·08–·10.	No. of Samples Examined.
Surface	9	27	41	18	5	.	.	22
Subsoil .	19	33	38	5	5			21

POTASH (K_2O) PER CENT.

Range	Below ·10.	·10–·20.	·20–·30.	·30–·50	·5–1·0.	1·0–1·5.	1·5 and above.	No. of Samples Examined.
Surface .	9	14	13	23	9	23	9	22
Subsoil .	.	.		5	30	40	25	20

LIME (CaO) PER CENT.

Range ...	Below ·10.	·10–·50.	·50–1·0.	1·0–2·0.	2·0–5·0.	5·0–10·0.	10·0–15·0.	15·0 and above.	No. of Samples Examined.
Surface	18	50	5	4	23			.	22
Subsoil	6		.	5	25	25	30	15	20

REPLACEABLE CALCIUM AND SODIUM.
(Per cent. of Total Replaceable Metallic Cations.)

Range ..		Below 5.	5–10.	10–20.	20–30.	30–40.	40–50.	50 and above.	No. of Samples Examined.
Surface .	Ca			4		9	35	52*	23
	Na	35	22	35	4	4	.		23
Subsoil (3rd foot)	Ca	9	18	59	9	5			22
	Na	5		..	4	45	41	5	22

* 26 per cent. in 50–60 per cent. range and 26 per cent. in 60 per cent. and above range.

The figures presented in the appendix for calcium carbonate are calculated from carbonate (CO_2) which is determined by treatment of the soil with cold, dilute acid. As the soil carbonate is in combination with magnesium, as well as calcium, expression of the result as calcium carbonate is not strictly accurate. The results presented do not render it possible to calculate the exact composition of the carbonate fraction, but an approximation may be made. Assuming that all of the calcium determined by digestion with concentrated hydrochloric acid occurs in the carbonate form, and that the remainder of the carbonate is combined with magnesium, it has been shown in Table E of the appendix that about 60 per cent. of the magnesium in the soil is accounted for. This indicates that some of the carbonate probably occurs as dolomite, an equivalent mixture of calcium and magnesium carbonates, or as magnesite, a crystalline form of magnesium carbonate, both of which are insoluble in cold, dilute acid and would not be determined by the method used for the estimation of carbonate.

Reference to Tables A-D of the appendix shows that the concentration of calcium carbonate in the fine earth fraction of the subsoil commonly ranges from 20 to 40 per cent. In addition is a considerable amount of calcium carbonate in the form of nodules and stones which also represents lime accumulation as a result of pedogenic processes. No estimate of this fraction has been made, but in the Milarup loam it probably constitutes from one-third to one-half of the soil mass in many instances.

No complete analyses have been made of the water soluble salts of soils examined in the course of this survey, but information has been reported for a large number of samples from the 3,500 Farms Scheme reconnaissance (Teakle 1939, p. 223). These results, together with data from this survey, show that the anions are predominantly chloride when the concentration of water soluble salts in the soil is above 0.4 per cent. If the chlorides be expressed as sodium chloride, the proportion as sodium chloride would be generally over 70 per cent. of the water soluble salts. At low concentrations the proportion of chloride decreases to about 20 per cent. This relationship between chlorides and the water soluble salts is illustrated in Fig. 7.

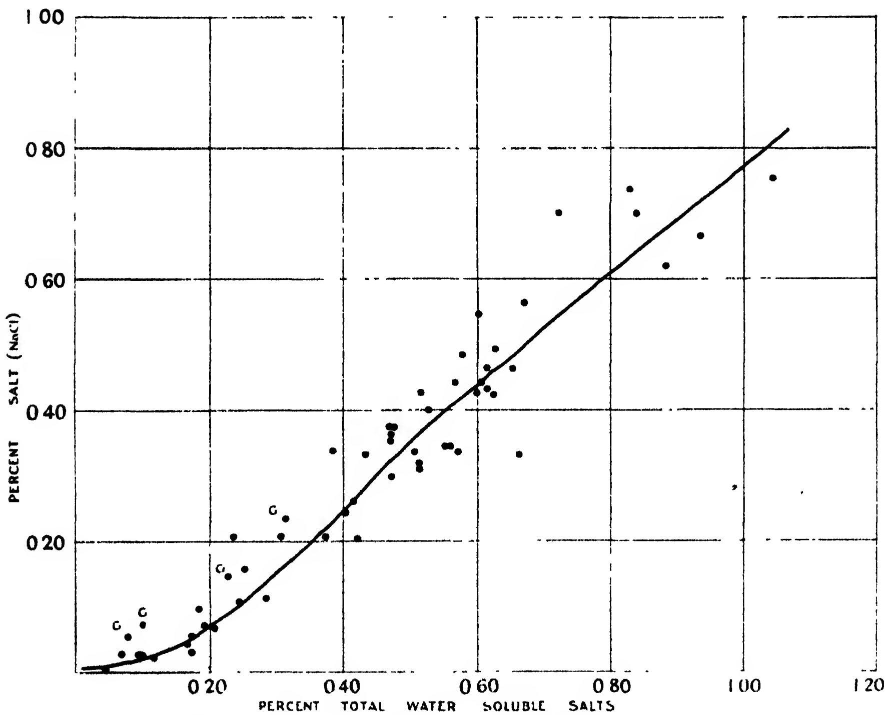

Fig 7.—Graph showing the variation in composition of the water soluble salts with increasing concentration. The four points labelled G represent the Gulson sandy loam and show an unusually high proportion of chloride.

Study of the distribution of water soluble salts with depth in the profile shows a very rapid increase in concentration from the surface to a depth of about two feet. Below that depth changes in concentration are relatively small, and increases in some cases and decreases in other cases are observed. Examples of four typical salt profiles are given in Fig. 8.

Taking the results of the survey as a whole, the salt concentration in the second foot is approximately double that in the surface foot. Early recognition of this fact is reflected in the standards adopted for low, medium and high alkali conditions.

With respect to the physical properties, with the exception of the Milarup series, the soils are low in the silt fraction as determined by mechanical analysis. It is interesting that the soils of the mallee zone of South Australia show the same characteristic. The coarse sand: fine sand ratio is somewhat variable, but in general the coarse sand is in excess of the fine sand. The variations between

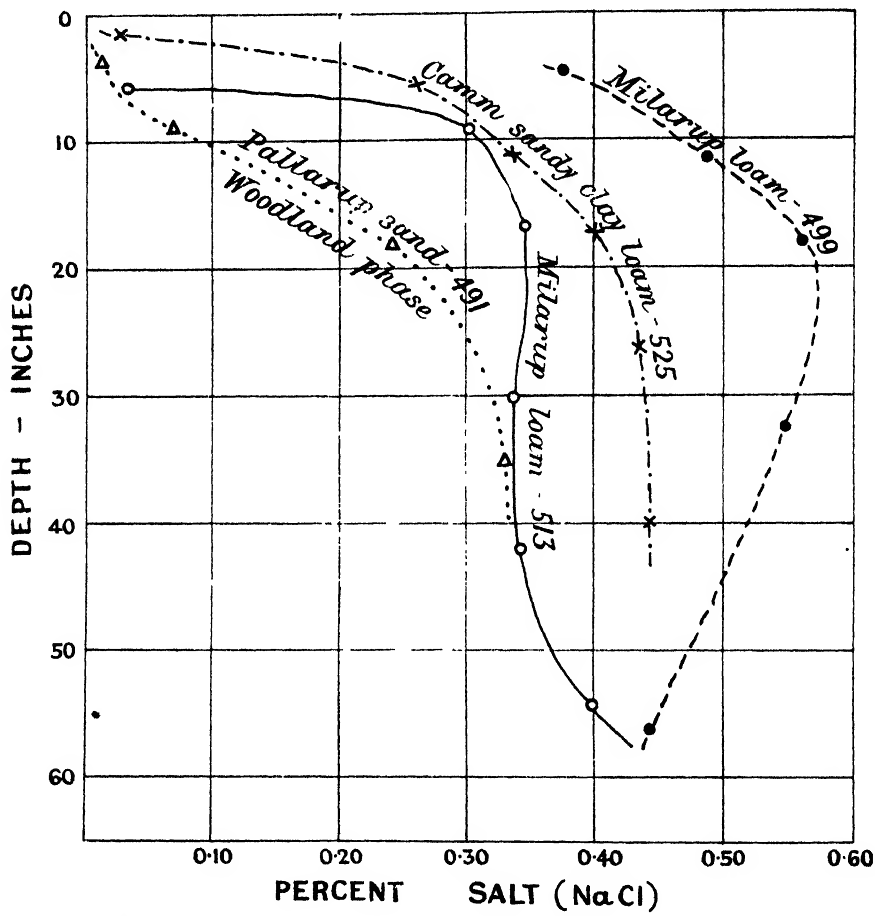

Fig. 8.—Graph showing the change in salt concentration with depth in the case of representative profiles.

the various soil series are not sufficient to indicate a wide variety of parent materials and generally the changes in the ratio with depth in the profile are hardly sufficient to be conclusive evidence of layering. It may be suspected that wind action has resulted in layering in the site selected to represent Milarup clay loam, but additional information to that supplied by the coarse sand; fine sand ratio would be necessary before this point could be established.

The Milarup series differs from the others in being relatively high in the silt fraction. The reason for this has not been determined, although it is known from a study of the results obtained by means of the hypobromite method for dispersion in mechanical analysis that a considerable proportion of the calcium carbonate falls in the silt grade. This would partly account for the silty nature of the Milarup soils as observed in the field but does not give complete explanation for the larger silt content of soils of this series.

The extent of the sandy surfaced types, in which the depth of the surface sand is not excessive, may be regarded as encouraging from the agricultural point of view. It has been established that the presence of a sandy surface results in considerable economy in moisture in that absorption is promoted and loss by evaporation is restricted. A considerable proportion of the soil types of the area, therefore, can be regarded as eminently suited for mixed farming under relatively low rainfall conditions.

3.—*The Salinity Problem.*

In a previous paper in this Journal, Teakle (1939) has shown that the woodland soils of the 3,500 Farms Scheme area south of Southern Cross are generally more saline than those of the present wheatbelt. There is no doubt that this salinity problem also affects the Lakes District and that the future manifestations of salt will be more serious than in the older settled areas. This does not mean, however, that all of the woodland and mallee scrub soils of the district are saline or useless for wheat growing. Far from it. The analyses made in the course of the soil survey show that the greater portion of the soils of the woodland and mallee group, other than those of the morrel woodland, are not saline and farming experience proves that excellent crops of wheat may be grown.

An analysis of the data from the soil survey shows that the situation with respect to soil salinity when the country was practically in the virgin state was as follows:—

(i) Soils of the salmon gum woodland.

Degree of Salinity.	Area.	Percentage.	
		Of the Group.	Of the Woodland and Mallee Scrub Soils.
	acres.		
Low	31,512	69·7	19·1
Medium	1,083	2·4	·6
High	12,573	27·9	7·6
	45,168	100·0	27·3

The bulk of the highly saline soils of this group are of the Camm sandy clay loam type (1A). These are frequently crabholey in nature, and experience in the Salmon Gums district, reported by Teakle and Burvill (1939), shows that under the rainfall conditions experienced, improvement after clearing is slow, if at all. However, in the course of the mapping of this district, certain areas

of the lighter textured Camm sandy loam (1C) were included with the saline salmon gum soils. As the Camm sandy loam soils are unlikely to give serious trouble due to salinity, it may be concluded that the figures given above for the saline types are slightly high, and in the light of experience at Salmon Gums, somewhat magnify the salinity problem in the salmon gum woodlands. Generally speaking, it will only be the heavier textured and crabholey phases which will be liable to serious damage from salinity.

(ii) *Soils of the Morrel Woodland.*

Degree of Salinity.	Area.	Percentage.	
		Of the Group.	Of the Woodland and Mallee Scrub Soils.
	acres.		
Low	19,107	32·0	11·6
Medium	256	·4	·2
High	40,337	67·6	24·4
	59,700	100·0	36·2

A large proportion of the soils of the morrel woodland, in particular the Milarup loam (4B) and the Milarup clay loam (9), must be regarded as unsatisfactory for wheat growing on two scores, one of salinity and one of unfavourable physical condition. Some of the low salinity group of this series, for instance the Milarup sandy loam, appear to be more suitable for wheat growing, but further data are required before any definite conclusions can be drawn.

(iii) *The Soils of the Gimlet and Merrit Thickets.*

Degree of Salinity.	Area.	Percentage.	
		Of the Group.	Of the Woodland and Mallee Scrub Soils.
	acres.		
Low	6,696	50·7	4·1
High	6,498	49·3	4·0
	13,194	100·0	8·1

These soils have been mapped as the Varley clay (8D) and the Barookee clay (8B). The Barookee clay (8B) covers the main area of highly saline soils in this group and must be regarded as generally unsatisfactory for agriculture in the district. The Varley clay is somewhat heavy for the general climatic conditions prevailing, but is otherwise suitable for farming.

(iv) *Soils of the Mallee Scrub.*

Degree of Salinity.	Area.	Percentage.	
		Of the Group.	Of the Woodland and Mallee Scrub Soils.
	acres.		
Low	32,247	69·0	19·6
Medium	5,286	11·3	3·2
High	9,198	19·7	5·6
	46,731	100·0	28·4

The bulk of the soils of the mallee scrub are relatively light in texture on the surface and salinity is unlikely to be serious, except on certain types of relatively restricted area. Even these, in many instances, will probably improve under a suitable cropping and pasture programme.

In addition to the area of mallee scrub detailed above, there are some 18,323 acres of low-lying country in depressions and adjacent to salt lakes which, in the virgin state, carry a type of mallee scrub vegetation. This is classed as the Hurlstone sand (5C) and is popularly referred to as lakey country. Owing to the rise in the salt water table following extensive clearing of the surrounding country, serious salinity is likely to develop in this type in the future. In older districts, considerable areas of country, similar in general features to the Hurlstone sand, have become practically useless in the course of a period of years, and, on that account, the type is mapped with the high salinity group.

Attention should be drawn to the fact that proximity to salt lakes does not necessarily indicate liability of soil types to salinity. Soil salinity is governed largely by the nature of the soil type, particularly with respect to the texture and structure, and the depth of the salt water table. In many instances, soil types adjacent to the salt lakes are of a sandy or light loamy nature, are well elevated, and, in consequence, may be developed for agriculture without danger of salt encroachment.

Only limited data of any degree of accuracy regarding crop responses on saline and non-saline soils of the district are available, and these are of little value as they refer to new land or land under its second crop. Enquiries made by Mr. A. Martin, the Agricultural Bank Inspector of the district, in 1931-32, were quite inconclusive as far as any correlation between crop yield and the salinity status of the farms could be determined. Deterioration of land as a result of salinity typically occurs with the passage of years, unless a suitable method of management can be discovered.

The situation with respect to salt was put in a general way by the then Chairman of the Agricultural Bank, the late Mr. A. McCallum ("West Australian," May 6, 1936), who stated that while many blocks which were severely affected by soil salinity were still "producing good crops, as the years have gone on, salt, to an increasing degree, had shown itself. . . . ."

4.—*Agriculture.*

The Lakes District is essentially an area suitable for mixed farming, with wheat production and stock raising as the principal activities. Sidelines may include pigs, poultry, etc., but transport difficulties will restrict diversification.

The better class soils, particularly those of the salmon gum woodland and the best of the mallee scrub types, are well suited to wheat growing and pasture production for stock raising. Wimmera rye grass, barley grass and the hardier types of clover and medics offer considerable promise. Experience in the older districts on similar soil types points to the sound nutritional value of the pasture of these soil types, especially for sheep and wool production. The results obtained in this district over the last few years confirm this opinion.

On the saline soils and snuffy morrel types, pasture production with a limited amount of cropping can be recommended on the basis of results on the Salmon Gums Research Station. Wimmera rye grass and trailing salt bush are of greatest promise, and experiments being carried out by Mr. A. S. Wild in the Lake Grace district point to the value of a number of other species. The despised barley grass is of very considerable value for early feed, particularly on the snuffy morrel types. As forage crops, barley and oats may be recommended. It is likely that the use of some cultivated crops will be necessary to maintain the vigour of the pastures on these soil types.

For the heath and wodjil soils rye is well worth a trial for feed purposes.

Encouraging results have been obtained from the use of pasture on saline soil types on the Salmon Gums Research Station. As a result of these experiments there is some evidence that a pasture cover so improves the soil conditions that satisfactory wheat crops may be obtained following a period under well-established pasture.

In the uncleared country the stock carrying capacity is very low but may be enhanced by light burning which increases production and improves the feed value of the various shrubs. Near the lakes, salt bush, when used as an adjunct to the improved pastures and stubbles, will be of value for stock purposes. It must be remembered, however, that salt bush must be handled with great care as overgrazing leads to rapid deterioration.

With respect to general agricultural practice, the experience of the wheatbelt will apply to the Lakes District. Fallowing will be necessary for wheat growing, as will also be the use of superphosphate and suitable cereal varieties planted at the correct sowing times. On account of the paramount importance of the surface soil, due to the chemical conditions discussed above, every care must be taken to control soil erosion. For this purpose over-cropping and over-stocking must be avoided and particular attention paid to pasture production as the means of restoring the soil after a period of cultivation. To this end, it is fortunate that the rainfall is reasonably reliable and generous. The spread is better than in the more northern agricultural areas of similar precipitation, and neither the winters nor the summers are severe. However, the rainfall records for the most northern part of the district, Emu Rock, are low and give warning of marginal conditions for mixed farming.

It is desirable at this point to discuss more fully the question of the soils of the morrel woodland. Frequent reference has been made above to the unsatisfactory agricultural reputation earned by these soils throughout the lower rainfall areas of the Western Australian wheatbelt. Although these soils are chemically the richest of the wheatbelt region, farming experience has proved them to be most disappointing. They produce a satisfactory growth of wheat during the wet winter months but the crop suffers in the dry spring ripening period, with resultant low grain yields. Good yields are obtained only in wet seasons.

The unsatisfactory returns are commonly associated with the snuffiness or powderiness of the surface and farmers who have had success in the handling of soils of this type have attempted to compact the surface, particularly by the use of stock, and also by the use of shallow working implements, over a period of years. However, progress is slow and the damaging effect of deep ploughing will be felt for many subsequent years.

The reasons for the unsatisfactory crop returns on morrel soils under low rainfall conditions are still obscure but a number of factors may be recognised:—

(1) These soils are very highly calcareous even on the surface, a fact which Teakle (1938) has suggested may be due to the supposed superior lime gathering propensities of the morrel timber. The occurrence of lime in the surface may be responsible for the unavailability of certain essential minerals for plant growth, with consequent nutritional disturbances of the growing crop. Experiments which have been carried out in the past have not yet pointed to any operative nutritional factor.

(2) These soils are powdery or snuffy when dry. They do not form the desirable crumb structure of good arable soils and moisture absorption is often restricted, due to hydrophobic properties.

(3) These soils show unusual capillary powers and raise water by capillary action more rapidly and to a greater height than do the other woodland soils with normal crumb structure. Furthermore, it seems that moisture will rise by capillarity in these soils from a moist subsurface in the absence of a definite water table. As such a large proportion of the soils of the morrel woodland in the Lakes District is highly saline in the virgin state, it is to be expected that, following clearing, surface accumulation of salt will result from the operation of these capillary powers. In other districts bare patches due to salt are probably more common in soils of this nature than in any other soil type.

It is indeed unfortunate that approximately half of the woodland soil types examined in the Lakes District belong to the morrel group and are of restricted value for cropping purposes. When developed, they must be regarded essentially as pasture soils; barley grass, wimmera rye grass and salt bush appear to be the most promising species.

It is unlikely that a satisfactory solution of the problems involved in the growth of satisfactory wheat crops on morrel soils will be obtained until the matter is given special attention by a team of research workers. There is no reason why a concerted attack should not yield positive results in the course of a few years and enable the fertility status of this extensive soil type to be more effectively used for the production of agricultural crops.

The water supply of the district is practically confined to excavated tanks or dams, except around the granite outcrops where wells occasionally may be located or rock catchments constructed. With the exception of the morrel types, the subsoil conditions in the woodland country provide good holding, and there should be little danger from salt water invading the dams, except on low-lying areas which are readily recognised as unsuitable for water storage.

Transport is a problem vital to the prosperity of the district and will always present difficulties on account of the distribution of the farming country. As explained above, the agricultural soils are largely confined to a valley which is very narrow over much of its length of 70 miles. This means uneconomical transportation for a district of little more than 100 settlers over a distance of 70 miles, unless railways can be built to serve farm lands further east. Under

present conditions it is necessary to develop a type of agriculture which requires a minimum of transport service, and this appears to be the policy of the settlers occupying the territory.

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APPENDIX A.

Mechanical Analyses and Chemical Data of the Soil Types.

The information with respect to mechanical analyses and chemical data for the type samples representing the main soils of the Lakes District are given in detail in Tables A-D. In securing this information the standard methods of analysis were used throughout.

Mention may be made of the fact that the quinhydrone method, using a one to one in the early work and later a one to two and a half soil-water suspension, was adopted for determination of reaction, and the sodium hydroxide dispersion method proved most satisfactory for the mechanical analysis.

Replaceable calcium and magnesium were determined by double extraction with normal sodium chloride solution. Replaceable sodium and potassium were extracted with normal ammonium chloride.

TABLE A.

MECHANICAL ANALYSES AND CHEMICAL DATA OF SOILS REPRESENTING THE PALLARUP SERIES.

Soil Type	Pallarup Sand—Woodland Phase (5B)								Pallarup Sand—Mallee Scrub Phase (MS).						
Serial No. ...	466	467	468	469	491	492	493	494	483	484	485	486	1051	1052	1053
Horizon	A	B	B	B	A	B	B	B	A	B	B	B	A	B	B
Depth (inches)	0–6	6–14	14–27	27–43	0–7	7–11	11–25	25–43	0–6	6–12	12–24	24–40	0–7	7–14	14–28
Mechanical Analysis—Percentage of the Air Dry Fine Earth															
Coarse Sand ...	52·5	29·5	27·4	22·4	63·4	40·1	20·9	22·5	51·6	38·7	23·4	20·4	59·5	42·0	34·3
Fine Sand ..	34·3	15·8	12·8	12·7	27·5	18·0	7·7	7·4	36·4	21·7	10·9	9·9	34·0	23·2	15·1
Silt ..	6·3	6·3	10·0	8·7	3·0	4·1	1·6	0·1	3·5	2·2	2·2	1·6	1·5	3·6	3·3
Clay ..	5·0	43·2	39·3	47·2	5·6	36·0	53·7	56·1	7·1	34·3	44·3	34·0	2·7	28·8	42·5
Coarse Sand / Fine Sand } Ratio ..	1·53	1·87	2·14	1·76	2·31	2·23	2·72	3·04	1·42	1·78	2·15	2·06	1·75	1·81	2·27
Chemical Properties—Percentage of the Air Dry Fine Earth.															
$CaCO_3$ (from CO_2)	·2	2·2	6·3	6·4	2	7	14·4	15·7	·4	1·2	14·6	29·6	·05	·16	2·15
Organic Carbon	·77	·25	·19	·12	·56	·51			·54	·26			·69	·34	
Total Nitrogen	·028	·029	·025	·02	·021	·025			·022	·022			·022	·015	
C / N } Ratio	27·5	8·6	7·6	6·0	26·7	20·4			24·5	11·8			31·4	22·7	
pH *	7·55	8·39	8·25	8·09	7·06	8·24	8·31	8·14	7·72	8·58	8·51	8·51	7·36	8·31	8·66
Constituents Soluble in Concentrated Hydrochloric Acid.															
P_2O_5	·005			·003	·004			·009	·005			·004	·013		·015
CaO ..	·091			2·88	·085			9·74	·097			15·1	·107		1·11
MgO	·054			·681	·122			2·08	·159			1·51	·086		1·01
K_2O	·277			1·85	·093			1·55	·200			1·14	·048		·78
Replaceable Metallic Cations															
Total m.eq. per 100 gm. Soil	7·21	21·69	22·25	23·83	3·95			25·83	5·12			16·18	3·69		18·81
Total m.eq. per 100 gm. Clay	144	50·3	56·6	50·5	70·5			46·1	72·1			47·6	137		44·3
Ca %†	42	19	15	12	67			22	66			13	65		13
Mg %†	40	35	34	33	29			31	11			27	29		41
K %†	6	15	16	19	4			9	9			19	6		11
Na %†	12	31	35	36	Trace			38	14			41			35
Total Water Soluble Salts—Percentage of the Oven Dry Fine Earth.															
T.W.S.S.	·042	·245	·373	·472	·033	·206	·403	·433	·093	·286	·513	·473			
NaCl	·007	·109	·206	·354	·010	·068	·242	·331	·025	·111	·310	·363	·01	·14	·23
NaCl / T.W.S.S. } Percentage	16·7	44·5	55·2	75·0	30·3	33·0	60·0	76·4	26·9	38·8	60·4	76·7			

* Quinhydrone electrode—soil : water ratio 1 : 1 for Serial Nos. below 1000, 1 : 2.5 for Serial Nos. above 1000.

† Per cent. of total replaceable metallic cations.

TABLE A—*continued.*

MECHANICAL ANALYSES AND CHEMICAL DATA OF SOILS REPRESENTING THE PALLARUP SERIES—*continued*

Soil Type	Pallarup Coarse Sandy Loam (M5).			Pallarup Gravelly Sandy Loam (M6).				Pallarup Sandy Loam (M1).			
Serial No.	1037	1038	1039	1047	1048	1049	1050	1043	1044	1045	1046
Horizon	A	B	B	A	B	B	B	A	B	B	B
Depth (inches)	0–2	2–18	18–26	0–1½	1½–7	7–21	21–42	0–2	2–8	8–21	21–35
Mechanical Analysis—Percentage of the Air Dry Fine Earth.											
Coarse Sand	49·3	24·2	17·6	50·6	28·6	18·8	20·1	54·9	37·8	22·5	9·1
Fine Sand	35·6	16·2	10·4	33·8	19·3	10·0	11·7	33·2	19·3	9·6	3·4
Silt	3·2	1·3	1	4·5	4·9	2·9	5·3	3·2	2·7	1·4	1·1
Clay	10·6	47·3	56·4	9·0	42·3	49·4	55·7	7·5	35·3	51·6	32·4
Coarse Sand / Fine Sand Ratio	1·39	1·49	1·69	1·50	1·48	1·88	1·72	1·65	1·96	2·34	2·68
Chemical Properties—Percentage of the Air Dry Fine Earth.											
$CaCO_3$ (from CO_2)	·110	5·10	9·50	·140	·560	13·1	·95	·047	·35	9·45	49·6
Organic Carbon	·84	·86		1·15	·89			·77	·65	..	..
Total Nitrogen	·034	·036		·045	·036	..		·027	·029	..	..
C / N Ratio	24·7	23·9		25·5	24·7			28·5	22·4	..	
pH*	6·40	8·31	8·38	6·92	8·17	8·17	8·06	6·92	8·21	8·57	8·58
Constituents Soluble in Concentrated Hydrochloric Acid.											
P_2O_5	·017		·019	·016			·024	·012	..		·013
CaO	·129		4·46	·142			·322	·160		..	15·0
MgO	·168		1·47	·169			·954	·207	..	..	12·1
K_2O	·151		·735	·109	..		·623	·171	..		·610
Replaceable Metallic Cations.											
Total m.eq. per 100 gm. Soil	4·73		25·14	6·29			25·30	4·79			15·13
Total m.eq. per 100 gm. Clay	44·7		44·6	70·0			45·4	63·8			46·7
Ca %†	69		20	44			7	53	..	..	4
Mg %†	24		38	47	..		47	40	..	..	41
K %†	6		12	4			8	6	..	..	15
Na %†	1		30	5		..	38	1	..	..	40
Total Water Soluble Salts—Percentage of the Oven Dry Fine Earth											
T.W.S.S.				...	..	..		..	..	..	
NaCl	·01	·24	·42	·04	·25	·50	·70	·01	·23	·41	·41
NaCl / T.W.S.S. Percentage				...	..	..		..		..	

* Quinhydrone electrode—soil : water ratio 1 : 1 for Serial Nos. below 1000, 1 : 2.5 for Serial Nos. above 1000.

† Per cent. of total replaceable metallic cations.

TABLE B.

MECHANICAL ANALYSES AND CHEMICAL DATA OF SOILS OF THE CAMM AND CARMODY SERIES.

	Camm Sandy Clay Loam (1A).										Camm Sandy Loam (1C).				Carmody Sand (7).			
Serial No.	525	526	527	528	529	530	211	212	213	214	504	505	506	507	536	537	538	539
Horizon ..	A	B	B	B	B	B	A	B	B	B	A	B	B	B	A	B	B	B
Depth (inches)	0–3	3–8	8–14	14–20	20–31	31–48	0–4	4–10	10–30	30–48	0–5	5–8	8–21	21–42	0–5	5–10	10–18	18–32
Mechanical Analysis—Percentage of the Air Dry Fine Earth.																		
Coarse sand	51 6	39·4	27 2	20 7	16·6	17 9	44 1	15·1	15 0	19 4	56 6	44 7	21 0	19·5	49·4	51·1	45·0	47·5
Fine sand . .	25·5	20·6	11 5	10 1	8 7	8 4	34 0	12·0	8·9	12 8	23·0	19·7	9·1	8 4	30·3	26·8	28·7	25·7
Silt .. .	6·1	4·8	2·5	1 6	1 2	1·4	6 5	3 7	2·1	1 0	7 6	8·4	5·2	6·4	3·4	3·4	3·6	3 4
Clay .. .	14·0	31·3	59·8	58 2	54·3	50 9	11 4	41 7	32·9	43 0	8 2	23·5	50 2	49 9	15·7	17·0	20·7	22·4
Coarse sand / fine sand } ratio ..	2 02	1 91	2 37	2 05	1 91	2 13	1·30	1 26	1 69	1·52	2·46	2·27	2·31	2·32	1·63	1·91	1·57	1·85
Chemical Properties—Percentage of the Air Dry Fine Earth.																		
$CaCO_3$ (from CO_2)	*Nil*	·1	2 8	2 7	14 5	18 8	·08	19 6	39 0	17 8	·1	·1	8·1	9 5	*Nil*	*Nil*	*Nil*	*Nil*
Organic carbon	·90	·59					1·31	1 26			1·49	78	29	23	·46	·40		
Total nitrogen .	·056	·044					·055	·078			·059	·056	028	011	027	·029		
C / N } ratio . .	16 1	13 4					23 8	16 2			25 3	13·9	10 4	20·9	17·0	13 8		
pH*	7·41	7 93	8·38	8 38	8 52	8 55	6 82	8 31	8 42	8 42	7 38	7 38	7 75	8 02	5·81	5·51	5·29	5·49
Constituents Soluble in Concentrated Hydrochloric Acid.																		
P_2O_5 .	·011				·009		·008			01	007			006	·005			·006
CaO	076				4·28		199			5 10	·151			4·95	·024			·005
MgO . .	396				3 20		·298			4·25	·296			1·48	·012			·009
K_2O	·438				1·73		203			735	319			1·43	·053			·061
Replaceable Metallic Cations.																		
Total m.eq. per 100 gm Soil	3 80				20 05		10·54			20 83	9 90	16 14	27 44	26·13	1·55			1 36
Total m.eq. per 100 gm. Clay	27·2				36 9		92·5			48 4	121	68 7	54 7	52·3	9·9			6·07
Ca%† .	47				8		52			4	42	23	19	15	57			18
Mg% .	10				24		38			35	36	42	37	36	19			62
K%† .	24				25		6			12	7	9	10	10	19			18
Na% . .	19				43		4			49	15	26	34	39	5			2
Total Water Soluble Salts—Percentage of the Oven Dry Fine Earth.																		
T.W.S.S. .	·096	418	508	530	·616	·608					069	·237	385	·517	·032	038	·050	·046
NaCl	027	260	333	400	433	·443					·029	·202	·338	·428	·006	007	·007	·017
NaCl / T.W.S.S } %	28	62	66	76	70	73					42	85	88	83	19	18	14	37

* Quinhydrone electrode—soil : water ratio 1 : 1, except for Serial Nos. 211–214, for which 1 : 2·5.

† Per cent. of total replaceable metallic cations.

TABLE C.

MECHANICAL ANALYSES AND CHEMICAL DATA OF SOILS REPRESENTING THE MILARUP SERIES.

	Milarup Loam (4B).																
Serial No.	470	471	472	473	495	496	497	498	499	500	501	502	513	514	515	516	517
Horizon	A	B	B	B	A	B	B	B	A	B	B	B	A	B	B	B	B
Depth (inches)	0–5	5–13	13–28	28–43	0–6	6–16	16–26	26–42	0–9	9–13	13–22	22–41	0–6	6–11	11–22	22–36	36–48
Mechanical Analysis—Percentage of the Air Dry Fine Earth.																	
Coarse Sand	40·6	33 3	32·0	27 0	19·8	14·9	11 7	10·2	26·1	23·3	21·7	19 5	38·5	30·7	28·9	22·5	22·1
Fine Sand	16·5	16·2	15·0	13·4	11·6	10·1	6·2	4·9	11·1	10·6	8·5	6·4	16·7	16·5	14·9	11·9	11·6
Silt	14·2	13·4	11 3	7 7	22·0	18 8	6·8	5·0	22·7	15·7	10 2	3·3	10·1	9·0	6·8	6·0	4·9
Clay	14·9	16·1	17·7	19 9	32·5	32·3	41 0	44·2	20·9	27·5	32 9	35·3	19·3	20·0	21·5	18·5	20·9
Coarse Sand / Fine Sand } Ratio	2·46	2·06	2·13	2·02	1·71	1 48	1·89	2·08	2·35	2·20	2 55	3 05	2·30	1·86	1·94	1·89	1·90
Chemical Properties—Percentage of the Air Dry Fine Earth.																	
$CaCO_3$ (from CO_2)	7 5	16·3	21·2	30·4	4·7	16·4	28·3	30 6	9·2	15·3	20·1	28·2	7·7	17 8	21·9	39·9	42·2
Organic Carbon	2·41	80	·47	·31	1·71	·59		.	1·47	·72			1·88	·96	..	..	..
Total Nitrogen	·143	056	·032	·015	·111	·052			·092	059		.	·127	·066	...	...	..
C / N } Ratio	16·9	14·3	14 7	20 7	15·4	11 3		.	16·0	12·2	.		14·8	14 5	..		.
pH*	8 36	8·42	8·60	8·51	7·92	8 31	8 34	8·29	8·25	8·28	8·49	8·59	8 00	8·17	8·41	8·58	8·41
Constituents Soluble in Concentrated Hydrochloric Acid.																	
P_2O_5	·033			·008	·022			·006	·018			·007	·025		...	·006	.
CaO	4·07			11·95	2 82			15·60	4·91			14·97	4 65	.	.	13·40	.
MgO	·170			4 56	·90			2 26	1·56	.	.	2·34	1·34	..		7·59	..
K_2O	1 10			1 06	1·80	.		1·51	1·59		.	1·20	1·03	..	.	·842	...
Replaceable Metallic Cations.																	
Total m.eq. per 100 gm. Soil	25·74	19·32	16 50	14·48	33 38			22·91	31·30	.		16·91	24·46		..	12·85	....
Total m.eq. per 100 gm. Clay	173	121	93·2	72·8	103			51·8	150		.	47·9	127	.	.	69·5	....
Ca%†	49	19	10	12	54			14	34		.	11	65	..	..	11	..
Mg%†	22	26	24	20	23			27	30		.	27	22		..	31	...
K%†	12	20	25	24	11			17	15	.	.	22	9	.	....	20	...
Na%†	17	35	41	44	12		.	42	21	.	..	40	4	..	..	38	....
Total Water Soluble Salts—Percentage of the Oven Dry Fine Earth.																	
T.W.S.S.	·421	·615	·569	·600	·513	·830	·840	·723	·471	·579	·671	·601	·192	·472	·560	·572	·556
NaCl	·203	·465	·443	·428	·319	·737	700	·700	·375	·486	·564	·548	·070	·297	·343	·336	·343
NaCl / T.W.S.S. } %	48 3	75·6	78·8	71 4	62 2	88 8	83·3	96·8	79·7	83·9	84·1	91·2	36·5	63·0	61·3	58·8	61·7

* Quinhydrone electrode—soil : water ratio 1 : 1 for Serial Nos. below 1,000 ; 1 : 2 5 for Serial Nos. above 1,000.

† Percentage of total replaceable metallic cations.

TABLE C—*continued.*

MECHANICAL ANALYSES AND CHEMICAL DATA OF SOILS REPRESENTING THE MILARUP SERIES—*continued.*

	Milarup Sandy Loam (4A).												Milarup Clay Loam (9).					
Serial No.	474	475	476	477	487	488	489	490	531	532	533	534	1031	1032	1033	1034	1035	1036
Horizon	A	B	B	B	A	B	B	B	A	B	B	B	A	B	B	B	B–C	
Depth (inches)	0–5	5–12	12–22	22–40	0–5	5–12	12–25	25–40	0–6	6–12	12–26	26–39	0–7	7–15	15–40	40–73	73–90	90–116
Mechanical Analysis—Percentage of the Air Dry Fine Earth.																		
Coarse Sand	41·6	29·4	19·1	16·3	38·0	27·5	20·6	20·4	54·4	47·3	37·6	33·1	14·2	8·6	7·8	4·4	4·8	6·9
Fine Sand	23·1	17·0	9·6	7·3	19·0	16·9	11·5	8·9	22·9	22·3	18·4	14·9	20·9	13·2	5·1	4·4	5·7	8·8
Silt	8·1	6·1	2·6	2·2	15·9	12·1	8·6	6·5	4·4	5·8	5·2	4·9	33·5	22·6	5·9	5·7	6·7	4·6
Clay	21·5	40·1	41·8	37·9	20·5	37·8	42·7	43·3	15·9	22·8	32·4	37·0	19·2	44·4	53·7	48·7	59·4	69·9
Coarse Sand / Fine Sand Ratio	1·80	1·73	1·99	2·23	2·00	1·63	1·79	2·29	2·38	2·12	2·04	2·22	·68	·65	1·53	1·0	·84	·78
Chemical Properties—Percentage of the Air Dry Fine Earth.																		
$CaCO_3$ (from CO_2)	*Nil*	2·0	22·3	37·8	·20	·50	13·8	19·5	·05	·10	3·6	5·0	·58	·75	21·8	32·3	14·8	·46
Organic Carbon	1·25				1·26	·57			·78	·34			1·52	·56				
Total Nitrogen	·060				·059	·035			·039	·027			·120	·039				
C/N Ratio	20·8				21·3	16·3			20·0	12·6			12·7	14·4				
pH*	6·40	8·14	8·57	8·73	7·58	7·92	8·14	8·27	8·03	8·07	8·45	8·45	8·40	8·66	8·34	8·28	8·14	6·74
Constituents Soluble in Concentrated Hydrochloric Acid.																		
P_2O_5	·009			·004	·014			·013	·017			·013	·057		·047			
CaO	·256			10·25	·489			9·97	·200			2·70	·76		10·5			
MgO	·524			8·60	·551			2·08	·126			1·42	1·26		3·36			
K_2O	·739			1·23	1·06			1·57	·512			1·28	·305		·817			
Replaceable Metallic Cations.																		
Total m.eq. per 100 gm. Soil	18·91			20·95	22·11			20·77	7·58			14·51	31·78		23·07			
Total m.eq. per 100 gm. Clay	88·0			55·3	108			47·8	47·7			39·2	165		43·0			
Ca%†	42			21	58			36	83			18	44		15			
Mg%†	40			26	24			24	2			22	26		28			
K%†	7			16	12			19	13			26	16		17			
Na%†	11			37	6			21	2			34	14		40			
Total Water Soluble Salts—Percentage of the Oven Dry Fine Earth.																		
T.W.S.S.	·166	·473	·663	·653	·116	·173	·183	·253										
NaCl	·041	·297	·331	·465	·021	·053	·096	·167	·015	·075	·150	·230	·02	·06	·61	1·28	1·95	1·39
NaCl / T.W.S.S. %	24·7	62·8	50·0	71·2	18·1	30·7	52·5	66·0										

*Quinhydrone electrode—soil ; water ratio 1 : 1 for Serial Nos. below 1,000 ; 1 : 2·5 for Serial Nos. above 1,000.

† Percentage of total replaceable metallic cations.

TABLE D.

MECHANICAL ANALYSES AND CHEMICAL DATA OF SOILS OF THE GULSON AND BAROOKEE SERIES AND SUBTYPES 1B AND 1D.

	Gulson Sandy Loam (1S).				Subtype 1D.			Subtype 1B.					Barookee Clay (8B).			
Serial No.	508	509	510	511	1040	1041	1042	519	520	521	522	523*	479	480	481	482
Horizon	A	B	B	B	A	B	B	A	B	B	B	B	A	B	B	B
Depth (inches)	0–7	7–13	13–23	23–33	0–2	2–18	18–26	0–2½	2½–8	8–22	22–27	27–40	0–8	8–22	22–36	36–44
Mechanical Analysis—Percentage of the Air Dry Fine Earth.																
Coarse Sand	31·3	30·1	29·8	24·4	41·3	19·8	31·9	46·6	28·4	16·9	23·3	23·7	21·2	14·6	15·7	16·8
Fine Sand	18·0	17·4	15·4	12·1	25·2	9·2	9·4	28·6	18·3	8·8	12·3	16·4	18·1	10·0	10·3	12·0
Silt	19·0	16·4	14·0	6·3	4·2	2·2	6·6	5·5	3·8	3·2	3·8	10·0	9·6	6·0	5·3	5·8
Clay	20·8	26·5	29·9	34·0	24·4	61·6	48·9	17·5	43·5	48·5	54·8	43·5	38·8	37·9	42·9	47·4
Coarse Sand / Fine Sand Ratio	1·74	1·73	1·93	2·02	1·64	2·15	3·39	1·63	1·55	1·92	1·89	1·44	1·17	1·46	1·52	1·40
Chemical Properties—Percentage of the Air Dry Fine Earth.																
$CaCO_3$ (from CO_2)	2·2	3·8	6·6	18·2	·11	12	·055	*nil*	·6	16·8	·8	*nil*	6·7	28·5	21·9	13·5
Organic Carbon	1·35	55			1·51	63		·85	63				1·04	·33	·18	21
Total Nitrogen	085	·048			070	034		·050	·043				056	·032	·022	·034
C/N Ratio	15·9	11·5			21·6	18·5		17·0	14·6				18·6	10·3	8·2	6·2
pH†	8·32	8·79	8·66	8·52	7·09	7·86	6·97	7·70	8·0	8·0	7·73	7·73*	8·31	8·36	8·25	8·14
Constituents Soluble in Concentrated Hydrochloric Acid.																
P_2O_5	·023			013	·019		015	·009					·004		Trace	..
CaO	1·60			7·42	·217		099	·135					3·01		6·18	
MgO	1·26			3·37	·452		456	·364					774		4·45	
K_2O	1·19			1·15	·385		497	·355					1·08		1·04	..
Replaceable Metallic Cations Air Dry.																
Total m.e.q. per 100 gm. Soil	27·83		18·18		14·96		13·28	11·32				16·60	26·45	22·36	22·33	24·94
Total m.e.q. per 100 gm. Clay	134		60·8		61·3		27·1	64·7				38·1	68·2	59·0	52·0	52·6
Ca %‡	55		12		32		10	47				7	14	10	6	5
Mg %‡	31		28		53		45	39				43	36	30	30	35
K %‡	12		19		7		12	9				11	11	11	13	10
Na %‡	2		41		8		33	5				39	39	49	51	50
Total Water Soluble Salts—Percentage of Oven Dry Fine Earth.																
T.W.S.S.	·078	·100	228	314				·172	306	·628	·904	800	·626	·882	·934	1·042
NaCl	·054	·074	148	235	·26	43	43	030	208	·494	·718	·715	·422	·62	·666	·752
NaCl / T.W.S.S. Percentage	69	74	65	75				17	68	63	79	89	68	70	71	72

* pH of 40–60-inch layer, 5·48.

† Quinhydrone electrode—soil : water ratio 1 : 1 for Serial Nos. below 1000; 1 : 2·5 for Serial Nos. above 1000.

‡ Per cent. of total replaceable metallic cations.

APPENDIX B.

Mechanical Analysis by the Hypobromite Method.

As many of the samples examined contained a considerable proportion of calcium carbonate in the fine earth fraction, a number of samples were examined by the hypobromite method and the results compared with the International Method. In the International Method calcium carbonate is destroyed by acid treatment and the removal of a considerable portion of the mineral fraction of the soil will undoubtedly affect any interpretation of the mechanical analysis. So that this important fraction of the soil minerals may be included in the mechanical analysis, the hypobromite method may be used, whereby the organic matter is destroyed and the colloids dispersed without the removal of the calcium carbonate.

In order to compare the results of the two methods the percentages of the fraction determined in mechanical analysis by the International Method have been calculated on the basis of these fractions plus calcium carbonate. The differences in the percentage of each fraction obtained by the two methods of analysis should give a measure of the distribution of the calcium carbonate between these fractions. These comparisons are set out in Table E, which shows:—

(1) The hypobromite method was considerably less effective than sodium hydroxide as a dispersing agent for the clays of these soils.*

(2) A considerable proportion of the calcium carbonate appears to fall in the silt fraction.

*Destruction by strong hydrochloric acid of the calcium carbonate of the sand fractions separated by the hypobromite method liberated a small amount of clay which was apparently trapped as the calcium carbonate was deposited in the soil mass. This fact accounts, in part, for the disparity in the clay figures for the two methods after making allowance for calcium carbonate.

APPENDIX C.

The partitioning of calcium and magnesium in carbonate fraction.

In Table F the analyses for carbonate, calcium and magnesium have been calculated in terms of chemical equivalents, so that the possible partitioning of the calcium and magnesium in the carbonate fraction can be calculated. The analyses of non-carbonate soils, or soils low in carbonate, show that the calcium content, other than in the carbonate form, is relatively low, probably of the order of magnitude of 0.1 to 0.2 per cent. It may reasonably be assumed, therefore, that the calcium in the calcareous soils was predominantly in combination with carbonate, and, for purposes of calculation, it is assumed that the total calcium is combined in this form. A certain amount of the magnesium will be combined in the non-carbonate soil minerals and the remainder will be located in the carbonate fraction. Portion of the magnesium in excess of that equivalent to the residual carbonate may be in the form of dolomite, and as magnesite, a crystalline form of magnesium carbonate. These magnesium compounds are relatively resistant to the attack of cold dilute hydrochloric acid, so that portion of the carbonate fraction in the soil may not have been determined by the Hutchinson-McLennan method used in this work. The amount of magnesium which could combine with the residual carbonate, as determined after combination with the

calcium, is shown in the final column. From these results it has been calculated that, on the average, approximately 60 per cent. of the total magnesium can be accounted for in this manner, leaving about 40 per cent. which must be in combination in non-carbonate minerals or as insoluble carbonates in the soil.

APPENDIX D

List of local and botanical names.

Local name.	*Botanical name.*
salmon gum	*Eucalyptus salmonophloia.*
morrel (red)	*E. oleosa var. longicornis*
morrel (black)	*E. melanoxylon*
gimlet	*E. salubris*
Kondinin blackbutt	*E. Kondininensis*
merrit	*E. Flocktoniae*
redwood	*E. oleosa var. transcontinentalis*
yorrell	*E. gracilis*
swamp gimlet	*E. spathulata*
York gum mallee	*E. foecunda*
sand salmon gum	*E. leptophylla*
mallees (white)	*E. dumosa*
" (black)	*E. oleosa*
" (red)	*E. eremophila*
" (ring gum)	*E. annulata*
boree (ordinary)	*Melaleuca pauperiflora*
" (forbor)	*M. quadrifaria*
broom bush	*M. uncinata*
umbrella bush	*M. cardiophylla*
blue teatree	*M. pentagona*
jam	*Acacia acuminata*
claybush	*A. sericocarpa* *A. Graffiana*
needle bush	*Daviesia aphylla*
centipede bush	*Templetonia sulcata*
salt bush	*Atriplex sp.*
hop	*Dodonea stenozyga*
quondong	*Santalum acuminatum*
daisy	*Olearia Muelleri*
rosemary	*O. revoluta*
navy bush	*Halgania lavandulacea*
boxthorn	*Lycium australe*
grey bush	*Cratystylis conocephala*
native cherry	*Exocarpus aphylla*
boronia	*Boronia xerophila*

TABLE E.

Differences in the results of mechanical analyses of soils of the Lakes District by the Standard method and the Hypobromite method.

The values for the individual fractions were obtained by calculating the Percentage on the total fractions plus Calcium Carbonate in the Standard method and on the total fractions in the Hypobromite method. The differences were obtained by subtracting the figures for the Standard method from those for the Hypobromite method. The algebraic sum of the differences for any one sample is equivalent to the percentage of Calcium Carbonate in the mineral fraction.

Soil Type	Cscl	Cscl	Csl	Psl	Msl	Msl	Msl	Msl	Msl	Ml	Ml	Ml	Ml	Ml	Ml	Mcl	1D
Serial No.	212	213	506	1046	474	475	476	487	488	471	472	495	496	499	500	1033	511
Depth (inches)	4–10	10–30	8–21	21–35	0–5	5–12	12–22	0–5	5–12	5–13	13–28	0–6	6–16	0–9	9–13	15–40	23–33
Coarse Sand	1.4	2.0	3.2	19.7	.5	-1.4	9.1	.9	-.4	2.4	3.3	1.3	2.0	-.1	-.8	5.4	3.2
Fine Sand	4.9	2.9	7.9	7.5	1.2	2.0	8.0	1.1	.2	4.9	7.4	8.1	7.8	3.3	5.3	6.6	9.4
Silt	16.4	26.7	30.6	28.2	8.1	8.9	13.0	7.0	7.7	7.9	9.0	13.5	13.3	8.8	16.5	17.3	17.6
Clay	-1.4	8.1	-33.0	-3.6	-9.8	-7.4	-6.7	-8.8	-7.0	1.9	2.1	-17.7	-5.3	-1.8	-4.5	-6.3	-11.0
Algebraic total (equivalent to $CaCO_3$)	21.3	39.7	8.7	51.8	nil	2.1	23.4	.2	.5	17.1	21.8	5.2	17.8	10.2	16.5	23.0	19 2

Cscl = Camm sandy clay loam.
Psl = Pallarup sandy loam.
Msl = Milarup sandy loam.
Ml = Milarup loam.
Mcl = Milarup clay loam.

TABLE F.

On the assumption that all of the Calcium is combined with Carbonate, this table shows the Total Magnesium and the amount of Magnesium that could combine with the Residual Carbonate in the soil.

Analyses and calculations expressed as chemical equivalents per 100 gm. Air Dry Fine Earth.

Serial No.	Soil Series.	Depth.	Carbonate.	Calcium.	Magnesium.	Magnesium which could combine with Residual Carbonate.
		inches.				
469	Pallarup ...	27–43	.128	.103	.034	.025
486	do. ...	24–40	.592	.540	.076	.052
494	do. ...	25–43	.314	.348	.104	—.034
1039	do. ...	18–26	.190	.159	.074	.031
1046	do. ...	21–35	.992	.536	.605	.456
1053	do. ...	14–28	.043	.040	.050	.003
214	Camm ...	30–48	.356	.182	.212	.174
507	do. ...	21–42	.190	.177	.074	.013
529	do. ...	20–31	.290	.153	.160	.137
470	Milarup ...	0– 5	.150	.145	.008	.005
473	do. ...	28–43	.608	.428	.228	.180
477	do. ...	22–40	.756	.366	.430	.390
490	do. ...	25–40	.390	.356	.104	.034
495	do. ...	0– 6	.094	.101	.045	—.007
498	do. ...	26–42	.612	.556	.113	.056
499	do. ...	0– 9	.184	.175	.078	.009
502	do. ...	22–41	.564	.535	.117	.029
513	do. ...	0– 6	.154	.166	.067	—.012
516	do. ...	24–36	.798	.478	.380	.320
1031	do. ...	0– 7	.012	.027	.063	—.015
1033	do. ...	15–40	.436	.375	.168	..061
508	Gulson ...	0– 7	.044	.057	063	—.013
479	Barookee ...	0– 8	.134	.108	.039	.026
481	do. ...	22–36	.438	.220	.222	.218
	Average ...	...	...	...	.146	.089
	Per cent. ...	...	...	...	100	60

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Stored-grain Pests.

C. F. H. JENKINS, Government Entomologist.

INTRODUCTION.

Stored foodstuffs such as grain, dried fruits and flour are constantly liable to the attacks of insect pests, with the result that the farmer, grain merchant, miller and grocer have a continual war to wage in order to keep their products in a wholesome condition.

At the present critical stage in Australia's history, the importance of storage pests, usually known to the trade as "weevils,'' is so vital that it is the duty of every individual to see that the utmost is done to combat the depredations of these tiny but nevertheless powerful enemies.

During the 1914-18 World War, millions of bushels of bagged wheat were stored in Australia on account of the lack of shipping space, and incalculable damage was done by mice and "weevil" attack. Due to the present war conditions there is every possibility of large stocks of wheat accumulating in this State, but we must profit from previous experience and see that rodent and insect damage is reduced to a minimum.

The farmer may think that this is a matter for the Government or for the merchant who holds the wheat, but the responsibility cannot be shelved in that manner, for although this view may be partly correct, the first responsibility lies with the farmer himself.

Before dealing with the methods which may be adopted to safeguard the grain, it will be well to know the names of the insects with which we are concerned, how they may be recognised and the way in which they affect the wheat.

Grain insects may be divided into two main groups which can be listed as follows:—

I. *Primary Insects.*—Those capable of affecting sound grain—
- Rice weevil (*Calandra oryzae* L.).
- Granary weevil (*C. granaria* L.)
- Lesser grain borer (*Rhizopertha dominica* Fabr.).
- Angoumois grain moth (*Sitotroga cerealella* Oliv.).

II. *Secondary Insects.*—Those incapable of attacking sound grain—
- Confused flour beetle (*Tribolium confusum* Jacq.-Duv.).
- Rust-red flour beetle (*T. castaneum* Herbst.).
- Saw toothed grain beetle (*Oryzaephilus surinamensis* L.).
- Flat grain beetles (*Laemophloeus* spp.).

There is a belief prevalent even in these times that "weevils" appear spontaneously in grain just as toads were believed by the ancients to be the product of mud and slime, and flies an inevitable sequel to filth. That there is absolutely no foundation for this will be seen from the life history details which follow. Clean wheat will remain free from insect attack indefinitely if no outside infection is permitted. Every "weevil" is derived from an egg laid by a female and there is definitely nothing spontaneous or mysterious about an outbreak, however obscure the source of infestation may be.

PRIMARY PESTS.

Rice Weevil (*Calandra oryzae* L.). (Fig 1.)

Sometimes known as the black weevil, this insect varies considerably in size, but seldom exceeds one-eighth of an inch in length. The size is readily gauged from a comparison with a wheat grain in the accompanying illustration.

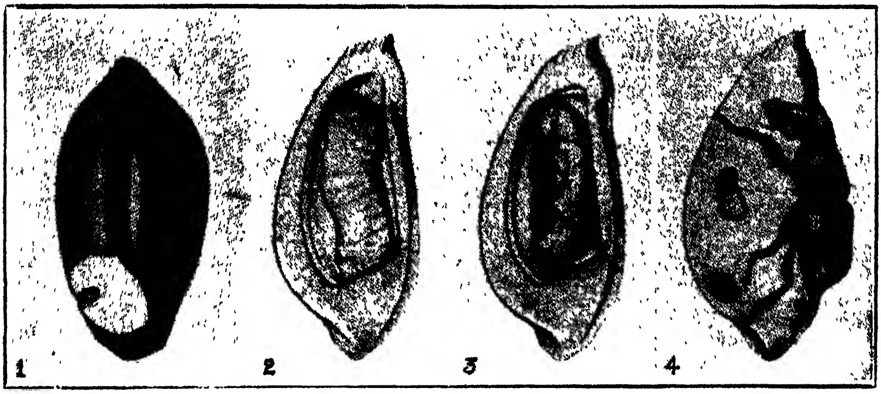

Figure 1.

Life stages of Rice Weevil in wheat. 1.—Grain dissected to show egg. 2.—Well grown larva. 3.—Pupa 4.—Adult feeding upon kernel. Note in 4 the hole in lower portion of kernel made by the adult on leaving the seed. The other shallower holes were made by the adult in feeding after emergence.

[From U.S. Dept. Agri.]

Being a true weevil the head is produced into a long snout at the end of which the mouth parts are borne. The colour varies from reddish brown to almost black and usually four light-coloured spots are distinguishable on the back. The thorax is densely pitted with round punctures.

Beneath the wing covers are a pair of fully developed wings and although the insect is seldom seen in flight, it is quite capable of adopting this method of progression.

In some countries indeed these weevils fly from the barns into the fields and attack standing grain, but careful observations have failed to reveal any such tendencies in this State and it is considered that summer conditions are unsuitable for the field activity of this insect.

The adult weevil can live for a considerable period, published figures varying from four to eight months, and during this time 300 to 1,000 eggs may be laid.

Before laying her eggs, the female bores a small hole with her mandibles into the wheat grain and therein deposits an egg. This is then covered with a gelatinous fluid which entirely plugs the hole. The fat, legless grub which emerges after three or four days feeds in the grain for about a fortnight and then pupates to emerge as an adult weevil at the end of about a week. It will be seen, therefore, that from egg to adult occupies from three weeks to a month. This time varies greatly according to temperature and humidity, and under cool conditions would be greatly increased. Below an average temperature of 50°F. weevil activity is considerably checked, but in this State the mean monthly temperature falls below 50°F. in but a few districts and then for only a short period. Weevils when working in wheat themselves tend to raise its temperature so that our winter conditions cannot be regarded as a serious check upon the pest.

Granary Weevil (*Calandra granaria* L.). (Fig. 2.)

The granary weevil is reddish brown to black in colour, and about the same size as the Rice Weevil from which it may be distinguished by the lack of the light spots on the wing covers and the presence of elongated instead of circular punctures on the thorax. Another important difference is the absence of flight wings.

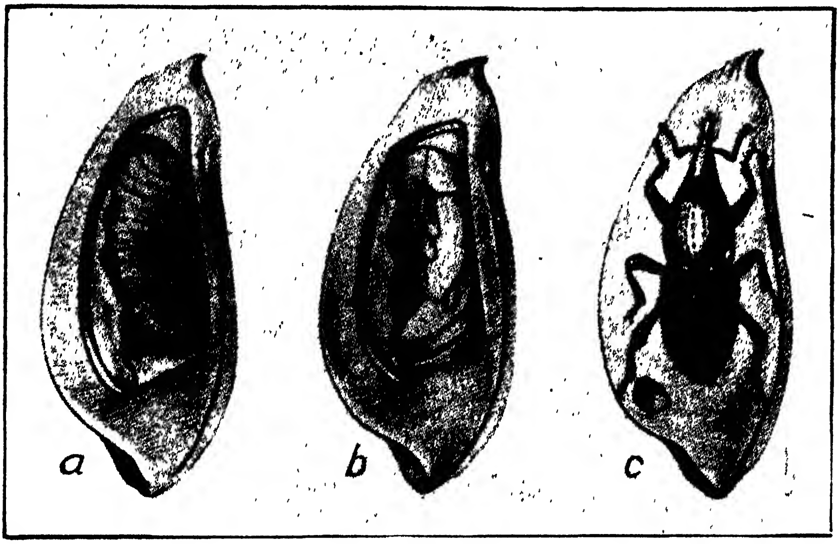

Figure 2.
Life stages of Granary Weevil in wheat a, Well grown larva, b, pupa; c, adult
[From U.S Dept Agri.]

As in the case of the rice weevil, the adults and grubs feed voraciously on grain, and the life history and habits of the two are so similar as to require little further comment.

The grain weevil, although usually associated with the rice weevil, prefers a temperate climate and considerable damage is not experienced locally from this species with the possible exception of some of the extreme southern regions.

The Lesser Grain Borer (*Rhizopertha dominica* Fabr.). (Fig. 3 and 3a.)

The lesser grain borer is not a true weevil, but belongs to the same group as many of the timber borers (Bostrichidae). It is one of the smallest grain pests, but one of the most serious in this country.

During the last war many shipments of Australian wheat were heavily infested by this beetle and it became known abroad as the Australian wheat weevil, although its native home is probably India. It is cylindrical in shape, dark brown or black, and about one-eighth of an inch in length.

Both the adults and the larvæ are responsible for serious damage to a variety of grains. The beetles may live for a period of up to four months and during that period lay 300 to 500 eggs. The eggs are laid singly or in clusters in the loose grain, and the young larvæ feed upon any floury material present or bore into grain damaged by the attack of the parents. They are generally incapable of entering a sound grain. From egg to adult is said to occupy about a month under favourable conditions, but may be extended to several months.

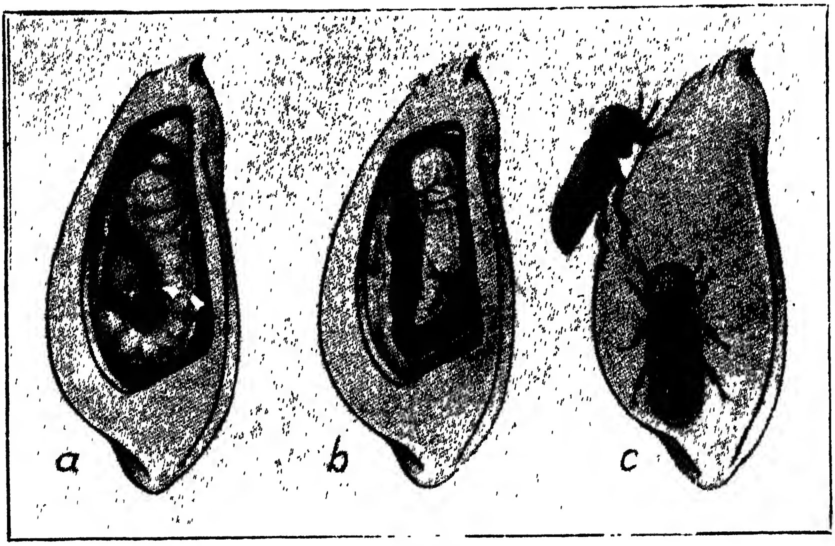

Figure 3.
Life stages of the Lesser Grain Borer. a, Well-grown larva. b, Pupa. c, Two Adults.
[From U.S. Dept. Agri.]

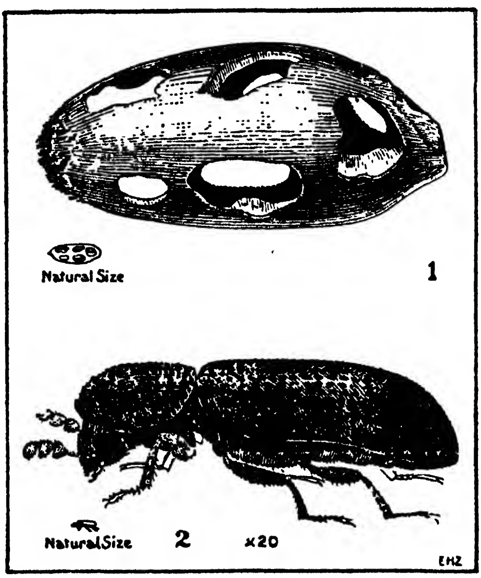

Figure 3a.
1.—Grain of wheat attacked by the Lesser Grain Borer. 2—The Lesser Grain Borer.
[From Ag. Gaz., N.S W.]

This pest is now widely distributed in Western Australia, having been first recorded at Fremantle in about 1916. The Geraldton zone was the first country area to be widely affected, but in recent years many other districts have reported the pest.

The Angoumois Grain Moth (*Sitotroga cerealella* Oliv.) (Fig. 4).

The Angoumois grain moth is buff or yellowish brown in colour with a wing spread of about half an inch. It is sometimes found infesting old hay stacks and is parasitised by the hay itch mite (*Pediculoides ventricosus*) which sometimes produces an annoying irritation during the process of chaff cutting.

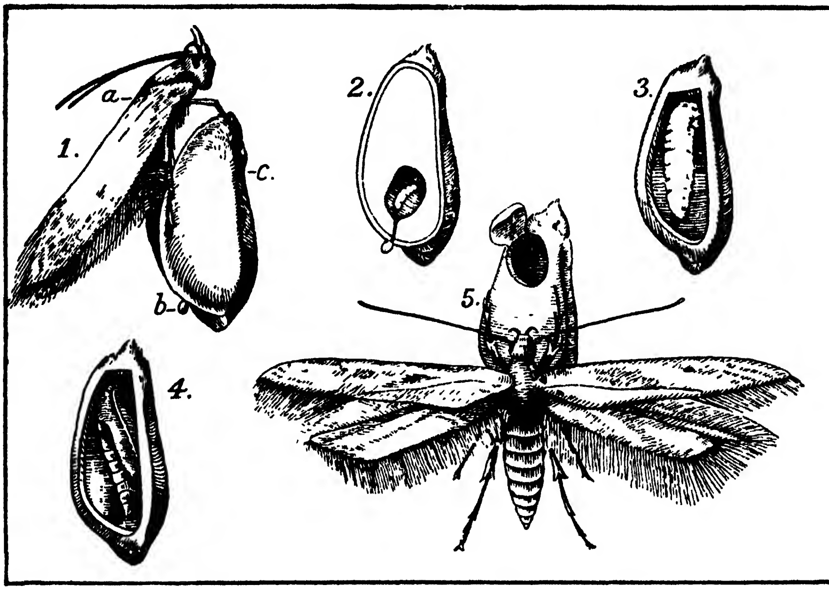

Figure 4.

1 Adult moth (a), egg (b), wheat grain (c) 2.—Section of wheat grain showing egg and entrance channel of young larva 3—Full-grown larva 4—Pupa 5—Adult moth after leaving by emergence hole as shown

[From U S Dept Agri]

Like the rice weevil, this moth is known in some countries to fly into the field to infest the standing grain, but so far no proof of this habit has been received locally, and we can confine our attentions to the insect as a pest in store.

An average of 40 or 50 eggs are laid by the female, but sometimes as many as 250-300 may be deposited. They are laid on or near the grain and the tiny grub on hatching bores into the kernel, often spinning a small cocoon at the entrance. When fully fed it eats out a channel to the seed coat, but leaves a small portion intact which is later pushed off as a lid when, after the pupal stage spent in a silken cocoon within the grain, the adult moth finally emerges. From egg to adult occupies about five weeks but again development is greatly slowed down under cold conditions, although the moth is said to be capable of working at lower temperatures than the weevils.

SECONDARY PESTS.

Confused Flour Beetle (*Tribolium confusum* Jacq. Duv.) (Fig. 5).

The confused flour beetle is a rather elongated shiny reddish brown beetle about one-seventh of an inch in length. The head and thorax are densely pitted and the wing covers ridged lengthwise with punctures sparsely distributed between the ridges.

Like the other storage pests mentioned it is not native to Australia but has been widely distributed by commerce and may be found attacking farinaceous materials in all parts of the world. It is principally a pest in flour mills, being incapable of feeding upon sound grain, but it will attack broken grains and kernels damaged by weevils and consequently helps in the final destruction of stored wheat.

The average life of a beetle is said to be 12 months or more, and females may lay over 400 eggs. These are deposited loosely, and being covered with a sticky secretion become covered with flour or grain dust and readily cling to the sides of bags and other receptacles so that clean material placed in them can rapidly be infested. In five to 12 days the eggs hatch into small grubs about 3/16ths of an inch long and resembling tiny wire worms. These pupate as naked yellowish-white pupæ and about six weeks after the egg was laid the adult beetle emerges. As with the other insects mentioned, this life cycle may be greatly prolonged by adverse conditions.

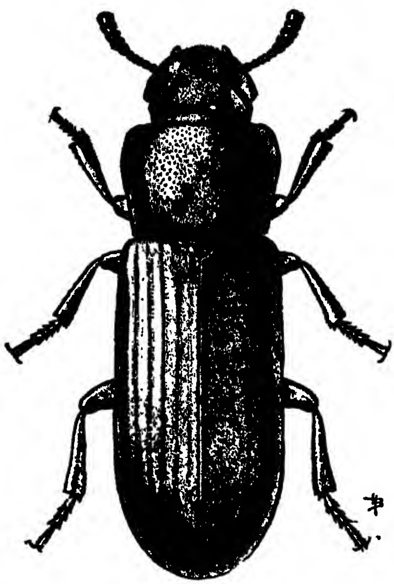

Figure 5.
The Confused Flour Beetle.
[From U.S. Dept. Agri.]

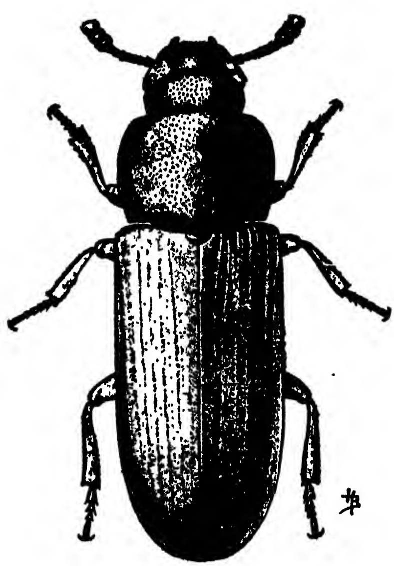

Figure 6.
The Rust Red Flour Beetle
[From U.S. Dept. Agri.]

Rust-Red Flour Beetle (*T. castaneum* (Herbst)) (Fig. 6).

The rust red flour beetle cannot be distinguished from the foregoing species without a magnifying glass, but whereas the antennæ of the confused flour beetle increase gradually in size towards the tip, those of the rust-red species increase abruptly at the tip, giving them a clubbed appearance. In addition, as can be seen from the accompanying illustrations, the sides of the head of the confused flour beetle are expanded and notched at the eyes whereas in this species the sides of the head are nearly continuous at the eyes.

The habits and life history of this species resemble very closely those of the confused beetle and so need not be further detailed.

The Saw-Toothed Grain Beetle (*Oryzæphilus surinamensis* (L.)) (Fig. 7).

The saw-toothed grain beetle is smaller than the flour beetles and of rather a darker brown colour. It may also be recognised by the six saw-toothed projections on each side of the thorax from which the popular name is derived.

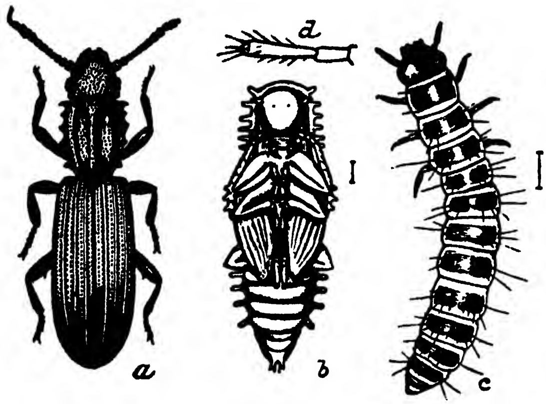

Figure 7.
Saw-toothed Grain Beetle a, Adult, b, Pupa; c, Larva.
[From U S. Dept. Agri.]

It is one of the commonest insects found in stored grain in this State, and also attacks many other foodstuffs such as dried fruits, nuts, etc.

The female beetles live from six to 10 months and may lay from 50 to 250 eggs which may be deposited loosely or in the crease of a wheat grain. After three or four days the larvæ appear and two weeks elapse before they spin a thin covering in which to pupate. From egg to adult occupies about four weeks under suitable conditions.

Like the flour beetles, this insect in its adult and larval stage feeds upon flour and damaged grain and assists materially in furthering the damage commenced by the weevils and grain borers.

Flat Grain Beetles (*Lœmophlœus* spp.) (Fig. 8).

The flat grain beetles are amongst the smallest of beetles found in stored grain, being only about one-sixteenth of an inch in length. The colour is reddish brown and the antennæ are relatively much longer than in any other beetles mentioned.

The eggs are laid loosely or in grain crevices and the tiny larvæ form gelatinous cocoons, covered with food particles in which to pupate. From egg to adult occupies about eight or nine weeks.

Mill Floss, Flour Bugs, and Bran Bugs.

The beetles described under the heading of "Secondary Insects" are variously known as flour bugs, bran bugs, and mill floss. They are often to be found swarming on bags and in wheat bins and their presence is undesirable, especially in flour mills, but to the farmer or wheat merchant they are not of much conse-

quence and so it is important to be able to distinguish between the primary pests which are able to destroy sound grain and the secondaries which follow in their wake.

This knowledge may save unnecessary anxiety and expenditure in control measures.

Figure 8
Flat Beetle
[From U.S. Dept. Agri.]

PREVENTIVE MEASURES.

Moisture Content.

It is generally known that wheat with a high moisture content is more prone to insect attack than that which is very dry, consequently the climatic conditions in Western Australia themselves afford one of the greatest protections to stored grain. Wheat when harvested may contain up to 12 per cent. moisture, but if stored in inland districts the figure may drop in the summer months to as low as eight per cent. or nine per cent. and the scarcity of summer rains favours the safe keeping of the crop. When, as in times of war, grain may have to be stored over one or two winters it is essential to see that no water is allowed to leak in, as damp wheat is one of the most favourable media for the rapid multiplication of weevils.

Much has been written about the figure at which weevil activity ceases on account of the lack of moisture in wheat, and about 10 per cent. is the figure usually quoted. There is much more work to be done on this matter before this can be taken as final, but it is certainly a guide to the degree of liability to attack, and wheat which can be kept in this dry condition is certainly less liable to damage than that with a higher moisture content.

Sanitation.

This is undoubtedly the most important factor in insect control and scrupulous sanitation should be observed right from the harvester box to the bakehouse door. All wheat should be cleared out of the harvester before it is put away and this ensures that when it is taken out next season clean wheat will not be contaminated before it enters the bags.

Second Hand Bags.

The mention of bags brings us to another extremely important point. In districts where bulk installations are present the same bags may be used year after year to cart to the siding. A little grain may be left in the bags when they are put away and this may be sufficient to harbour enough weevils to cause trouble the following year.

When finished with, bags should be turned inside out, thoroughly shaken and brushed, and hung away from any grain. They will then be quite clean and safe when needed later. If there is any reason to suspect that bags have contained weevilly wheat, they should be given special treatment and, if possible, placed in boiling water for five or ten minutes as this will kill all stages of insects that may be present and cause only the slightest shrinkage of the bag.

Store houses and sheds should be thoroughly swept of all old grain and refuse and treated with some suitable insecticide, and new wheat should never be stacked near that of another season. Where possible wheat should be stored on a sound grain-proof floor, so that seed cannot trickle through on to the ground beneath and so be out of reach of the broom.

Conveyances, such as railway trucks and lorries should not be overlooked as sources of trouble, as wheat and insects harboured in cracks and runners can easily be responsible for infesting fresh consignments, or even during their passage about the countryside, bringing contamination to clean storage sites.

To carry out the above instructions may seem irksome and fiddling, but if clean wheat is put into a clean container and no infested material is allowed to contaminate it, there will be no trouble from weevils. Never was the saying "Prevention is better than Cure" more worthy of observation than in the case of combating storage pests, for once a serious outbreak occurs, its control cannot be obtained without great expense, labour and loss.

A few weevils in the bottom of a bag may be enough to infest a whole bin or even a shipment, and so every farmer should strive to see that his carelessness is not the cause of a widespread loss.

Storage Methods.

The bulk storage of grain has much to recommend it for the prevention of insect attack, especially if the bins or silos are of a type that can be readily fumigated or cleaned. On this account steel or concrete bins are desirable, for the walls and floor can be made practically insect-proof and if thoroughly cleaned before being filled, clean wheat can only be contaminated from the top. The infestation will not penetrate to any great distance, as the weevil is said to be unable to penetrate further than about 5 feet, and the Grain Moth could only work in a very superficial layer.

Wooden silos are sometimes bored into by various insects; *e.g.* the Grain Borer, and cracks also offer a suitable harbour from which it is difficult to dislodge pests by any other means than fumigation, hence as little wood work as possible should be employed in constructing grain receptacles, and for farm purposes iron tanks are probably the most satisfactory containers available.

CONTROL.

Probably the most universal control treatment for grain pests is fumigation, but other treatments such as heat and insecticides have their place. Many other methods, including electricity and sifting, have been attempted, but without encouraging results. The latter may free the wheat from adults, but does not deal with the eggs and other stages in the grain; hence reinfestation soon follows.

Fumigation.

For this method to be effective the container to be treated must be more or less gas tight. Carbon bisulphide and hydrocyanic acid gas are the two most common gases used. The latter, being lighter than air, has poor penetrating properties and is more suitable for fumigating containers and mills than quantities of bulk wheat. Temperature is an important factor in fumigation, and a temperature of at least 70° to 75° is desirable for good results, as anything lower tends to reduce the efficiency of many fumigants. The volatilisation of fumigants may be increased either by spraying them into the fumigation chamber or by vaporizing the liquid by the application of heat in an apparatus called a vaporizer.

Carbon Bisulphide.

This gas which is heavier than air is very inflammable and explosive and hence requires considerable care in its use. The method of application is to pour the desired amount of liquid into shallow pans or pieces of sacking and place them on the top of the grain. If the depth of grain is greater than five feet, it is desirable to introduce the fluid by means of a pipe with outlets at suitable distances and in this way the gas which is given off will penetrate to all parts. Moist grain may be injured in its germination properties by this gas, and the baking quality of flour is said to be sometimes injured by the vapours, but this may be prevented by airing the flour before baking.

Carbon bisulphide should be applied at the rate of 1 lb. per 25 bushels of grain, or 4 lbs. per thousand cubic feet of space to be fumigated. The wheat should remain sealed for 48 hours.

Hydrocyanic Acid Gas.

This is chiefly used in this country for fumigating flour mills as the fire hazard is too great when carbon bisulphide is used. Cyanide, however, is very toxic to humans and must be used with great care. The gas may be generated by what is known as the "pot method" or from a number of proprietary preparations.

The standard formula for preparing the gas is as follows—

Sodium cyanide, 1 ounce.

Commercial Sulphuric Acid, 1½ fluid ounces (3 tablespoonfuls).

Water, 2 fluid ounces.

In the case of a mill each storey is treated as a separate unit and made as airtight as possible, but as the gas tends to rise the dosage on the bottom floor should be somewhat increased and the upper ones somewhat decreased. The dosage may be worked out on the basis of 1 lb. of cyanide to 1,000 cubic feet of space for the ground floor.

In preparing the mixture the sulphuric acid should be poured into the water and not vice versa, and the cyanide should be suspended over the earthenware crock, containing the liquid, in a paper bag and lowered in as the door is being closed.

A granular form of cyanide known as Cyanogas G is recommended for mixing with wheat when entering silos at the rate of 1% by weight, and other preparations such as Zyklon B and liquid Hydrocyanic Acid may be used as sources of this fumigant.

Grain or buildings treated with Hydrocyanic Acid Gas should be sealed for at least 12 hours and from 24-36 hours if possible.

Chloropicrin.

This gas is also known as tear gas and has given considerable promise as a fumigant. It is non-inflammable and heavier than air, hence it has the good points of carbon bisulphide without the drawbacks of the latter. It should be applied at the rate of 2 lbs. per 1,000 cubic feet of space in airtight bins, the dosage being increased if leakages are unavoidable.

The gas is said to have a deleterious influence on the baking qualities of flour by retarding yeast activity.

Ethylene Oxide used at the rate of 2 lbs. per 1,000 cubic feet of space for 12 to 24 hours is another well recommended fumigant, but it has a detrimental effect upon the germination of grain required for seed.

Carbon Dioxide.

This gas has proved very effective as an insecticide and was first used extensively during the last World War to control wheat insects in South Australia. Wheat stacks were enclosed in malthoid and carbon dioxide was pumped in in quantities sufficient to maintain the concentration at about 15 per cent. This concentration had to be maintained for at least three days to prove effective. It was later found that if the stacks were made sufficiently airtight, the respiration of the wheat grains plus the weevil activity would generate sufficient carbon dioxide to eventually prove lethal to insect life.

Methyl Bromide.

This is said to be even more toxic to the granary weevil than hydrocyanic acid. It is non-inflammable and hence should have a future as a fumigant. It is only in comparatively recent years, however, that its use has been advocated, and its extreme toxicity to man has militated against its general use.

Sulphur Dioxide.

Although an effective insecticide, sulphur is not very satisfactory as a fumigant, as apart from its tarnishing effect upon metals, it adversely affects the milling properties of flour and the germination of seeds.

Mixed Fumigants.

Different fumigants are mixed with the purpose either of reducing the fire hazard or increasing the toxicity. Carbon tetrachloride or trychlorethylene have been largely used in this direction, but recent investigations have shown that these mixtures are liable to change by fractionation, resulting in unsafe or ineffective fumigants and so the practice of using these substances for compound fumigants is losing favour.

The gas most generally advocated now is carbon dioxide. A 10 per cent. addition to ethylene oxide, for example, reduces the inflammability slightly while the addition of 90 per cent. entirely eliminates the fire risk.

Mixing Fumigants and Grain.

Bulk grain is sometimes treated in this way. During loading or turning a material which will slowly give off the fumigant is introduced in measured quantities. Calcium cyanide which reacts with water vapour and carbon dioxide to give off hydrogen cyanide has already been referred to, but another suitable chemical is ethylene oxide cooled by mixing with solid carbon dioxide. Proprietary prepara-

tions of this mixture have been sold in Europe under the names of "Etox" and "T Gas" and in America as "Carboxide." A third chemical used largely in Germany is magnesium phosphide which generates phosphine by reaction with water vapour.

Loss of Efficiency in Fumigants.

In addition to leakages which were usually considered to constitute the most serious loss, it has been shown that absorption may account for an even greater reduction of the fumigant. The rate of absorption differs with different commodities and is particularly high in the case of flour. Exact determinations of the absorption rate, etc., are important in determining the dosage of a fumigant and the amount of aeration required after treatment to dissipate harmful residues.

General Rules to be Observed when Fumigating.

1. **See that the container is as airtight as possible.**
2. **Do not fumigate wet or immature grain if it is desired for seed purposes.**
3. **Air foodstuffs or buildings as much as possible after treatment.**
4. **Take all necessary precautions with inflammable or highly toxic fumigants.**

Insecticides.

The insecticides which can be recommended for use against grain pests are limited, as their residue must not be toxic to humans or such as to taint the flour or wheat.

Sprays.

Kerosene-pyrethrum sprays, such as the many commercial fly sprays, are effective and may be used in empty bins, etc., where a little airing is possible before the grain is received.

White Oil.

White oil was primarily prepared for use against insect pests on fruit trees, but it has been shown to be very effective in killing weevils and also rendering grain treated with it relatively immune to attack.

Wheat dipped in white oil and water 1 part to 10 was not attacked by weevils under laboratory conditions, and a high percentage of mortality resulted when this oil was used as a spray at 1 to 30.

Dusts.

Much research has been conducted recently into the use of so-called "insect" dusts for the control of grain pests. One of the first to gain recognition and to be tested extensively for several years in Germany and Russia was a proprietary silica dust known as "Naaki" dust. The fine grains of silica adhere intimately to the insect and are believed to cause death either by mechanical action or by their dessicating properties or by a combination of both. Various forms of powdered silica have since been experimented with as well as types of colloidal clays such as bentonite.

In the use of these dusts it is usually recommended that the bins be thoroughly treated at the rate of about 1 lb. to 80 square yards of surface and that the powder be mixed with the wheat at the rate of 1%.

Much research is still necessary into the use of these dusts and other insecticides, and these avenues are at present receiving considerable attention from research workers.

Heat Treatment.

Heat treatment is one of the most effective ways of dealing with insect pests in wheat. It has been shown that at a temperature of 120° F. maintained for 3 hours will kill all stages of weevils, while 130° F. for 30 minutes is also effective.

Higher temperatures are more rapidly effective, but anything above 145-150° F. may be detrimental to the wheat. It is, of course, essential that the whole bulk of wheat be raised and maintained at the temperature cited.

Sifting.

Winnowing wheat is often suggested as a control for weevils, but it is little more than a palliative. The light grains and adult insects may be sifted out or blown away, but the grains containing eggs and larvae still remain, so that although the resulting sample may appear to be weevil-free, unless it is used immediately it will again give rise to a crop of beetles.

Pickling.

The pickling of wheat for the control of fungus diseases has been found to also constitute a very effective safeguard against "weevils." Copper carbonate dust used at 2 ounces to the bushel and the various mercurial pickling agents have proved effective insecticides. This method of control is, of course, only practical for seed wheat, as pickled wheat is not suitable for milling or for stock.

SUMMARY.

Primary insects are those capable of injuring sound grains-

1. Rice Weevil.
2. Grain Weevil.
3. Lesser Grain Borer.
4. Grain Moth.

Secondary insects infest grain already damaged or attacked by primary pests—

1. Flour Beetles.
2. Saw Toothed Grain Beetle.
3. Flat Beetles.

Prevent infestation by—

1. Cleaning out bins, trucks, bags, etc., thoroughly before putting in fresh wheat.
2. Hanging bags over a wire when not in use instead of piling them on the floor.
3. Fumigating, spraying or giving heat treatment to bins, trucks or other receptacles which have contained weevily wheat.
4. Keeping wheat under dry conditions.
5. Never storing new season's wheat near that of a previous season.
6. Never mixing old and new season's wheat.

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The Control of Wild Turnip (*Brassica Tournefortii*) in the Wheat Crop by the use of Copper Sulphate and Sulphuric Acid Sprays.

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Introduction.

The occurrence of the weed in Australia is mainly confined to Western Australia, although during the last few years it has been recorded in other States, where it is also causing concern. It is believed by some that this plant was first introduced into this State, about 1916, from Mediterranean countries, such as Palestine, Egypt or Tripoli, where it is common.

Although this weed probably made little progress in the first few years following its introduction, it is now apparent that by 1927 or 1928 it had become firmly established in parts of the Kellerberrin and Merredin districts. In 1929 it was officially identified and its seriousness realised, and was immediately gazetted a noxious weed for the whole State.

Despite the precautions taken and the warnings issued, it quickly spread throughout the main wheatbelt, where conditions were highly suited to its growth, until now it occurs to a greater or lesser extent in all districts from Ajana in the north to Salmon Gums in the south. In the wetter and more westerly districts it does occur, but so far has not reached the serious proportions or caused the same difficulties or losses in cropping, that it does in the more easterly wheatbelt districts.

This plant has been fully described by the Government Botanist (Mr. C. A. Gardner) in the Journal of the Department of Agriculture, W.A., Vol. X, September, 1933, pp. 409-419. In the same article, cultural methods of control were dealt with very fully by Mr. G. L. Throssell, Agricultural Adviser. Such methods have been successfully adopted by many farmers, but in many cases they have been only partially effective owing mainly to the manner in which the mature plant breaks off at the base and readily rolls along in the wind for miles, dropping seed as it travels. This is probably the worst feature of this weed where the usual cultural methods of control are carried out. Good fallowing methods and cultivation will not prevent reinfection of the land from badly infested areas considerable distances away. This difficulty is accentuated in years when the opening rains are late and farmers are forced to sow on a dry seed bed without a germination of weed seeds having occurred which would enable the young plants to be killed by cultivation before the crop is sown.

The following information made available by the C.S.I.R. (A.B. Cashmore 1936 unpublished) is pertinent to the question of variable germination frequently recorded under field conditions.

To discover the conditions favouring germination in *Brassica Tournefortii*, a germination test was undertaken. The treatments employed included incubation at four temperatures—20°C, 25°C, 28°C, 35°C— and treatment with concentrated

sulphuric acid for five and 10 minutes with subsequent incubation at 25°C. Laboratory temperatures sometimes exceeded 20°C so that seeds in the lowest temperature incubator were subject to slightly fluctuating temperatures. Germination was carried out in moist sand in Petri dishes. The results are presented in the following table:—

Treatment.	% Germination in— 3 days.	4 days.	5 days.	6 days.	7 days.	10 days.	21 days.
20° C.	9·25	13·25	13·50	13·75	...	...	14·00
25°	0·75	1·50	1·75	...	...	2·00	2·25
28°	...	0·50	1·00	...	1·25	...	1·50
35°	...	...	0·25	...	...	...	0·25
25°—Acid 5 mins. ...	26·66	40·00	46·00	47·33	50·00	52·66	58·00
25°—Acid 10 mins. ...	53·33	59·33	62·00	65·33	...	...	66·00

In the temperature treatments four replications of 100 seeds each were used; in the acid treatments 50 seeds were sown per dish and germinated in triplicate.

The results indicate that *Brassica Tournefortii* requires relatively low temperatures for germination and that the sample of seed tested, from Nangeenan, Western Australia, contains a high proportion of hard seed. This characteristic, ensuring discontinuous germination, possibly accounts for the persistence of the species in the wheat districts of Western Australia.

Spraying Experiments, 1937-1939.

In view of reduced yields and the difficulties experienced during harvesting operations and the failure in many cases to control the weed by ordinary cultural methods, it was decided in 1936 to commence experiments in association with the C.S.I.R. to test the efficiency and economics of controlling this weed by means of various chemical sprays.

1937 *Experiments.*

A suitable site was chosen on Mr. M. V. Cahill's property at Nangeenan, in the Merredin district, and sown with the wheat variety "Totadgin" at the rate of 45 lb. per acre and superphosphate at 120 lb. per acre on May 13th. It was anticipated that there would be a good growth of wild turnip on the area selected, but to ensure this, seed of this plant was mixed with the superphosphate and sown at approximately 4 lbs. per acre. On June 30th the plots for the following treatments in the form of a 6 x 6 Latin square were laid out on the area—

Unsprayed control.
Sprayed 3% sulphuric acid.
Sprayed 3% sulphuric acid, plus agral.
Sprayed 5% sulphuric acid.
Sprayed 7½% sulphuric acid.
Sprayed 3% copper sulphate.

The spray treatments were applied at 100 gallons per acre by knapsack sprays on July 1st and 2nd. Conditions throughout the Eastern Wheatbelt amounted to practically a drought during 1937, and consequently from the point of obtaining grain yields, the experiment was a failure. However, on October 1st,

counts were made of the turnip plants in all plots by taking at random ten sections each four links square in each plot. The results are tabulated hereunder:—

TABLE 1.

Spray Treatment.	Counts.	
	No. of Turnip Plants per square link.	Percentage.
Nil	3·9	100
3% Sulphuric Acid	3·7	95
3% Sulphuric Acid and Agral ...	3·6	92
5% Sulphuric Acid	1·9	49
7½% Sulphuric Acid	1·0	26
3% Copper Sulphate	1 1	28

These results show that only the 5% sulphuric acid, 7½% sulphuric acid and 3% copper sulphate have had any significant effect on the wild turnip. The 7½% sulphuric acid and the copper sulphate were more effective than the 5% sulphuric acid.

1938 *Experiments.*

The experiment was again conducted on Mr. M. V. Cahill's property at Nangeenan. The procedure was similar to that adopted in 1937, except that the very early maturing wheat variety "Noongaar" was sown and the rate of wild turnip seed increased from 4 to 7 lb. per acre. The spray treatments tested in addition to the unsprayed controls, were 2% copper sulphate, 3% copper sulphate, 5% sulphuric acid and 7½% sulphuric acid. The experiment was laid out in the form of a randomised block with five replications. Again, however, as in 1937, seasonal rains were extremely light, so much so that by the middle of September crop growth was very poor and all the wild turnip and other weed in the control plots had dried off. Hence the experiment from the point of view of determining the effect of the various spray treatments on the control of wild turnip was practically valueless. The plots were harvested, however, to ascertain the effect of the various sprays upon the resultant grain yield.

The yields obtained are set out in Table 2 hereunder:—

Spray treatment	Average Yield per acre.	
	Bushels.	Lb.
Control	8	54
2% copper sulphate	8	54
3% copper sulphate	8	6
5% sulphuric acid	7	38
7½% sulphuric acid	7	33

The yields are very low and reflect the poor seasonal conditions experienced. It would appear from the results that the sulphuric acid and 3% copper sulphate treatments have had a slightly depressing effect on the resultant crop yield. It

must be remembered, however, that these plots received a definite check when sprayed which was not followed by any good rain to assist their recovery.

1939 *Experiments.*

In view of the inconclusive results which had been obtained at Nangeenan owing to the adverse seasonal conditions, it was decided that in addition to the experiment at that centre, further sites would be selected in other districts, so that in the event of similar conditions prevailing at Nangeenan, as in the past two seasons, it would be possible to transfer the spraying experiments to areas where conditions were more favourable. This provision was indeed fortunate as very poor germination of wild turnip was obtained on the site selected at Nangeenan.

Two other sites were therefore selected, one on Mr. R. Clausen's property at Kununoppin, and the other on Mr. P. C. Paterson's at North Baandee, and arrangements made for conducting the experiment in duplicate. At each centre the following treatments were laid out in the form of a randomised block with seven replications, giving 35 plots each 64 yards x 4 yards:—

Unsprayed—control.
Sprayed—2% copper sulphate.
Sprayed—3% copper sulphate.
Sprayed—5% sulphuric acid.
Sprayed—7½% sulphuric acid.

At North Baandee the land was a red loam which had previously carried salmon gum (*Eucalyptus salmonophloia*) with a slight mixture of gimlet (*Eucalyptus salubris*). It was fallowed in July, 1938, with a rigid tyne cultivator, spring tyned in March, 1939, and seeded with a combined cultivator drill about mid May with the variety "Gluclub" at 47 lb. per acre and superphosphate at 90 lb. per acre.

The soil on the Kununoppin experimental area was a sandy type, originally timbered with sandy salmon gum (*Eucalyptus leptophylla*) and mallee (*Eucalyptus* spp.). It was cultivated with a spring tyned implement about the middle of May and seeded at the end of that month with a combined cultivator drill with the very early variety "Noongaar" at 55 lb. per acre, and superphosphate at 80 lb. per acre.

Spraying.

At North Baandee the wheat was further advanced than was desirable for the experiment. There was a good quantity of turnip present in various stages of growth, from the 4-5 leaf stage down to newly germinated plants with occasional large plants up to two to three inches in diameter. The crop had stooled well and appeared to be getting away from the weed. It was doubtful if the wild turnip would have had any very adverse effect on the wheat crop. Spraying was carried out on July 12th and 13th. Both days were very sunny and all plots were sprayed in bright sunlight. No rain fell during the night, but there was a heavy dew.

At Kununoppin, both wheat and wild turnip were in the stage of growth desired for the experiment. The wild turnip was very plentiful and was expected to have a very adverse effect on the wheat yield. Spraying was carried out on July 17th. The day was cloudy and none of the plots was exposed to bright sunlight until the following morning. No rain fell either during the day or night and there was practically no dew.

Observations After Spraying and During Growth.

In both experiments the effect of the 7½% sulphuric acid was evident very shortly after sprayings, both the wheat crop and the wild turnip showing signs of burning. On the day following spraying all plots sprayed with sulphuric acid showed evidence of burning. The wild turnip appeared to be dead and the upper leaves of the wheat plants badly dried. The crop in the plots sprayed with 7½% sulphuric acid were appreciably more affected than that in those sprayed with 5% acid. No visible difference was apparent between the plots sprayed with copper sulphate and the control plots.

In early August an examination of the experimental sites indicated that both acid treatments had exercised considerable control of the wild turnip, but also had adversely affected the crop growth. In the copper sulphate plots some effect could be seen both on the wild turnip and the crop, but in all cases it was mild and a satisfactory control of the weed was certainly not indicated.

Results.

During August, ten 1 square link counts of both wild turnip and wheat plants were made in each plot. These determinations are given in Table 3 hereunder:—

TABLE 3.

Table showing the mean number of plants per square link, together with these expressed as a percentage of the control plot.

Counts made on 7th August, 1939.

Location of Experimental Site.	——	Treatments.					Difference necessary for Significance. (P = ·05)
		Control.	2% Copper Sulphate	3% Copper Sulphate.	5% Sulphuric Acid.	7½% Sulphuric Acid.	
R. Clausen, Kununoppin	Wild Turnip	8 97	2 88	1 84	0 73	0 30	0 93
	(Percentage)	100	32	20	8	3	10·4
	Wheat	3·76	4 63	4 74	4·64	3 77	Not significant
	(Percentage)	100	123	126	124	100	Not significant
P. C. Paterson, North Baandee	Wild Turnip	8 07	3 36	1 34	1 40	Nil	1 77
	(Percentage)	100	41	17	17	Nil	21 9
	Wheat	4 10	3 77	3 57	3 66	3 09	Not significant
	(Percentage)	100	92	87	90	75	Not significant

Before harvest all plots were reduced to 60 yards in length. A six-foot strip down the centre of each plot was harvested and the weight of grain obtained from that area was recorded. The harvest results are given in Table 4 hereunder:—

TABLE 4

Wheat Yield Results expressed as bushels per acre

Location of Experimental Site.	Treatments.					Difference necessary for Significance. (P = ·05)
	Control.	2% Copper Sulphate.	3% Copper Sulphate.	5% Sulphuric Acid	7½% Sulphuric Acid.	
R. Clausen, Kununoppin (Harvested 21st December, 1939)	8·98	10 18	9·61	9·77	9 63	Not significant
P. C. Paterson, North Baandee (Harvested 18th December, 1939)	26·62	24·08	25·38	24·67	24·84	0·85

Discussion.

It is evident from Table 3 that all spray treatments significantly reduced the density of the wild turnip population, and further, the sulphuric acid sprays have been more effective than the copper sulphate sprays. At Kununoppin the 5% sulphuric acid destroyed 92% of the turnip, and the 7½% acid 97%, while at North Baandee the figures for the two treatments are 83% and 100%, respectively.

In the case of copper sulphate sprays, the 2% treatment at Kununoppin destroyed 68% of the turnip, and the 3% spray 80%, whilst at Baandee, the figures were 59% and 83%, respectively. At Nangeenan in 1937, 7½% sulphuric acid destroyed 74% of the turnip, and the 5% 51%, whilst the 3% copper sulphate spray was equally effective as the 7½% sulphuric acid spray. Considering the results of the three experiments together, Nangeenan (1937), Baandee (1939), and Kununoppin (1939), it can be concluded that the control exercised by the copper sulphate sprays used were only partially effective when compared with sulphuric acid.

None of the spray treatments had any effect on the number of wheat plants present. However, observations made immediately following the time of spraying showed that all the sulphuric acid sprays had caused injury to the wheat plants. Inspections later in season showed that whilst these had recovered from the initial injury, they were still backward when compared with the plants in the control plots.

Reference to Table 4 shows that at Kununoppin the spray treatments had no significant effect on the wheat yields. The plots were located on unfallowed land. At the time of spraying wild turnip was present in a dense stand and the wheat plants were four to five inches high. If from the counts made in August, it can be assumed that the turnip was present in such quantities as to reduce the wheat yield, then it can be concluded that any advantage gained by the reduction in the turnip population resulting from the sprays must have been offset by the injury to the wheat plants caused by those sprays.

In the case of the North Baandee experiment, the sprayed plots yielded significantly lower than the unsprayed ones. The soil was of good quality and had been well fallowed, and although the turnip was plentiful (eight plants per square link), the crop was well advanced and at the time of spraying it did not appear as though the turnip would have any effect on the resultant crop yield. This observation is substantiated by the yield of 26½ bushels from the control plots.

In the experiments described, the destruction of the wild turnip by the various sprays has not led to increased crop yields, owing to the injury caused to the wheat by these sprays. From one year's operations, this process must be considered uneconomical. However, it might be argued that the benefits and advantages to be obtained from practically a total destruction of the wild turnip by spraying in one year could only be assessed from the results over a number of years. This would imply that in subsequent years the wild turnip on these areas would be much lower than if it had not been sprayed, and control by the usual cultural operations would be reasonably effective and satisfactory. The amount which germinates in any year, the percentage of hard seeds and also the amount of reinfestation by blowing from other paddocks would have an important bearing on this point.

Bearing in mind all these aspects, it is considered that the use of sulphuric acid sprays are unlikely to offer an economical method of control of wild turnip under Western Australian wheatbelt conditions, except possibly on isolated badly infested areas which may be a menace to adjoining clean areas.

Summary.

The results of three years' (1937-1939) experiments with the use of copper sulphate and sulphuric acid sprays for the control of wild turnip (Brassica Tournefortii) in the wheat crop are presented.

These experiments have shown that 83 to 100% of the turnip can be killed by the use of sulphuric acid sprays at the strength of 5% and 7½% applied at the rate of 100 gallons per acre. A higher level of control has apparently been obtained by the stronger spray, but from the practical and economic aspect it must be considered that the 5% solution is highly effective.

Copper sulphate sprays at the strength of 2% and 3% have appreciably reduced the number of turnip plants, but these sprays must be considered only partially successful when compared with the sulphuric acid sprays.

None of the sprays tested have had any significant effect on the actual number of wheat plants, but they have caused injury to the plants. The grain yields from the sprayed plots were not appreciably higher than those of the unsprayed controls. This suggests that the injury to the wheat plants was severe enough to offset any advantage which may have resulted from the destruction of the weed.

Experiments conducted by Mr. A. B. Cashmore of the C.S.I.R. regarding the effect of temperature and acid treatment on the germination of wild turnip seed are recorded.

The economic and practical aspects regarding the control of wild turnip by spraying are discussed.

Acknowledgments.

As mentioned in the introduction, this investigation was a joint one conducted by the Department of Agriculture and the Division of Plant Industry of the Council for Scientific and Industrial Research who supplied the necessary material for the experiments. The Chief of the Division, Dr. B. T. Dickson, and his Officers were responsible for the original plans and at all times offered material assistance with advice and criticism. Our thanks are also due to Messrs. Cahill, Paterson and Clausen who readily made their land available for the experiments.

The Cultivation of Flax for Fibre.

H. G. ELLIOTT, Agrostologist.

Introduction.

In June, 1940, the Minister for Agriculture (Hon. F. J. S. Wise) was asked by the Commonwealth Department of Supply and Development if this State would be able to assist and co-operate in the production of wax for fibre. The reason for this request can be given by examining the effect of the War on the availability of supplies of flax fibre both in Australia, and in the United Kingdom. World production of flax fibre in 1937-38 was 806,000 tons, of which more than 700,000 tons were produced in Soviet Russia, and only 8,000 tons (1% of the total) in the British Empire. This dependency on foreign source of supply made itself felt in two stages, each of which has been met by appropriate action by the Commonwealth Government. In the earlier months of the War supplies from Russia and the Baltic Ports generally were severely restricted, resulting in a short supply in

Australia for essential requirements such as covers for railway trucks, fire hoses, water bag canvas, linen thread or flax yarn, as well as a wide range of flax products demanded for the equipment of the fighting forces.

The Department of Supply and Development took prompt measures to meet this shortage by encouraging producers in Victoria to raise the area of 2,000 acres at the time under cultivation to an area of approximately 8,000 acres, in districts considered most suitable for production. Following on this, a new and more serious restriction was brought about by the over-running of the countries of Western Europe by the Nazi forces, involving the loss to Great Britain of Belgian and Dutch supplies. The United Kingdom Government immediately forwarded an urgent request to Australia that assistance should be given to make up this deficiency, and in addition to an offer to purchase as much as would be available of the production of the 8,000 acres then being planted, Britain asked the Commonwealth to plant an additional 400 tons of flax seed which was available in London, and offered to purchase the resultant crop from the 13,000 additional acres as fibre.

With regard to the 8,000 acres which were sown for local consumption, the Department of Supply and Development has entered into contracts to purchase the flax fibre of approved quality from any processor able to supply it, and will arrange for the sale of the fibre to spinners who will supply the Australian market for yarn. For the current year the price paid to the farmer for his flax straw will be the same as was paid last year, namely £5 per ton for straw of suitable quality, which from experience is a payable price. In fixing the price of the straw at this level when overseas quotations for fibre have mounted above those ruling before the outbreak of the war, the Government had in view the desirability of avoiding price booms with the consequent danger of price slumps. It was intended to avoid unfair discrimination between farmers who would otherwise be able to reap a good war-time profit and those not so fortunately placed. Having decided against profiteering in all forms, the Government saw no reason to allow temporary exploitation of the flax market to take place to the detriment of the community and against the permanent interests of the industry.

Area Selected.

Following on this application for the development of the industry in Western Australia, our Department believed that an opportunity existed for the development of the flax growing industry. The area selected this year for the production of flax was that extending from Waroona to Dardanup. The principal reason for selecting this area was knowing the seed would not arrive from England until the beginning of August, it was considered advisable to utilise, where possible, irrigation land for the production of flax during this season.

To get the necessary good and ready response the new flax farmers would need to be guaranteed some minimum return for undertaking production, provided they complied with instructions regarding preparation of land, sowing, harvesting, etc., given by responsible officers of the Department of Agriculture. In making this appeal to farmers to co-operate in this patriotic war effort, the Commonwealth Government has made it clear that to sow in unsuitable districts would be only to waste precious seed, time and opportunity, and would in fact hamper rather than help the nation's war effort. Within the districts selected, the following conditions have been laid down:—

(1) that seed shall be made available by the department to farmers at 15s. per bushel plus rail freight from the port of arrival, the cost of the seed to be deducted from the farmer's crop cheque when settlement is being effected.

(2) that the Commonwealth agrees to purchase the whole of the resultant crop from the farmer on a basis of £5 per ton standard quality, and reserves the right to discount any crop which does not come up to the standard quality requirements, and pay premiums up to £1 per ton on better quality straw.

(3) that provided the farmer performs all necessary cultural operations to the satisfaction of the State Department of Agriculture, he will be guaranteed a gross return of £4 10s. per acre, this guarantee to be subject to reduction in respect of any operations not performed.

Advisory Committee.

The Commonwealth has already appointed an Advisory Committee to assist in the production of flax, comprising:—

Mr. J. A. W. Stevenson, Department of Supply and Development, Chairman.

A representative of the Council for Scientific and Industrial Research.

A representative of the Department of Agriculture in each State where this scheme is operating, and

Messrs. R. B. Hogg and E. H. Kinnear, Jun., representing the processors.

The State Departments of Agriculture will provide the machinery for controlling the sowing and cultivation of the crop, and will be assisted by local committees appointed by the Commonwealth Government in areas selected as suitable. The Department of Supply and Development, through the Advisory Committee, has taken steps for the local manufacture of fresh equipment and the establishment of mills for processing the increased crop which has been contemplated.

Flax.

There is a great deal of confusion in the minds of people as to what flax is, and what it looks like. True flax (*Linum usitatissimum*) is often confused with New Zealand flax, a coarse fibred plant (*Phormium tenax*), entirely different from flax and not comparable to it in value. Phormium fibre is a relatively cheap product and is used in goods like binder twine. Unfortunately, the term "flax" is a misnomer. Hemp has a fibre that is actually stronger than flax, and competes with it to some extent in industry, and like flax is regarded as a soft fibre, while Phormium is a hard fibre, extracted by mechanical decortication. In contrast, the fibre of flax is normally extracted from the rest of the tissue forming the stem by taking advantage of bacterial action which occurs under favourable conditions of temperature and moisture, or by a new process of economical retting which has been developed by the Council for Scientific and Industrial Research.

Flax was probably first grown in Western Australia in the years 1905-6 at Narrogin and Brunswick Junction. Very little work was done following the initial stages of growing of this plant until 1918, when another small scale experiment was carried out in the Katanning, Narrogin, Brunswick, Merredin and Chapman areas. The results of these experiments were not encouraging at the time, this probably being due to not selecting suitable areas and suitable strains of flax seed. Further experiments have been carried out from time to time in this State, and during the year 1939 an experiment was conducted at the Denmark Research Station with a number of varieties to determine if any variations occurred under these conditions. The variety known as Liral Crown which is extensively grown

to-day in Victoria gave the best results from the point of view of length of fibre. Straw with a length of up to 3ft. 9in. was obtained. Further experiments are being conducted this year at Denmark, and also at Manjimup. These experiments were initiated prior to any information being obtained that it would be necessary for us to grow a much larger area for Commonwealth needs.

Climatic Conditions.

The average annual rainfall should be in the vicinity of 30-38 ins. Cool moist spring, together with good finishing off rains at the end of the growing period are essential for best fibre production.

Soil.

It is recommended that the best soil is one which can be considered a medium loam overlying clay, being reasonably fertile, moist and well drained. Rich soils have a tendency to cause the crop to grow coarsely with a liability to lodge. Excessively dirty land should be avoided on account of weeds, more particularly such tall-growing weeds as radish, docks, wild oats, etc.

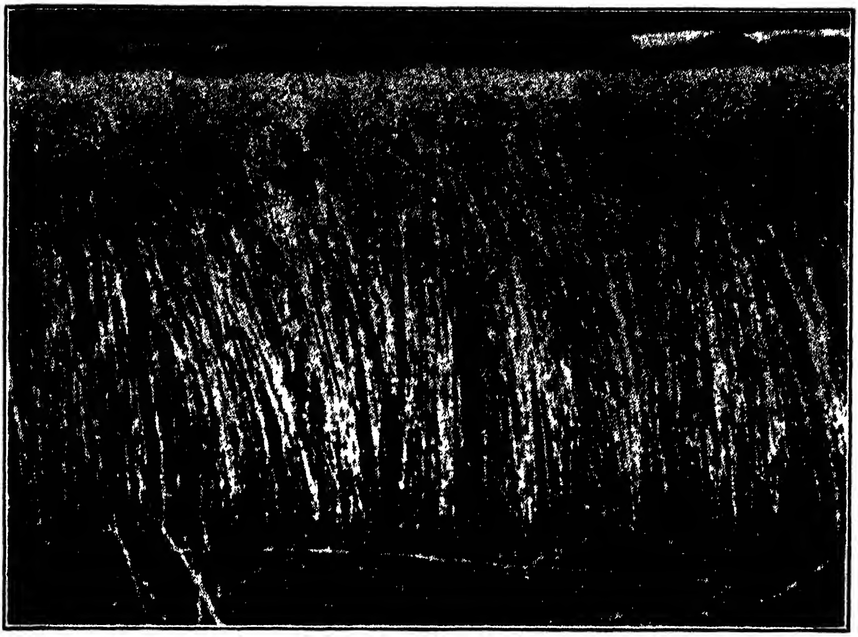
Rotation.

Flax should not be grown on the same ground more often than once in five years, as otherwise the land tends to become flax-sick, due to the accumulation of a fungus disease (*Fusarium lini*), which causes flax wilt. The flax, therefore, should be used in rotation with other crops, such as potatoes, peas, etc., or the paddock left out in pasture. It has been stated that flax is a soil robber, but in recent years this has been authoritatively contradicted. The theory of fertility depletion appears to have arisen in cases where flax was grown for several years in succession on the same land, poorer crops being recorded each year. This decrease in yield has been found to be due to the increasing incident of the abovementioned flax wilt in the soil, rather than to fertility depletion. As flax does not cover the ground in its early stages, it will not suppress any strong growing weeds such as those mentioned. Care, therefore, should be taken in selecting clean ground for flax, as weeds cut with the crop reduce its market value.

Diseases of Flax.

Linseed or linen flax is subject to a number of diseases, the most serious being the fungus disease *Fusarium lini,* known as flax wilt. Generally speaking, this is the most serious menace to the successful cultivation of linen flax. Infected plants simply wilt and die at any stage of growth. Seed harvested from an infected crop carries the disease fungus which enters the soil in which the seed is sown. There it can remain, and it is capable of infecting a crop planted in this soil after 11 years. If both seed and soil are free from the disease, there is little prospect of infection from either source. Another disease which causes quite a considerable amount of damage is flax rust (*Melampsora lini*) which forms bright orange or shiny black patches on the leaves and the stems. When it attacks the stem, it greatly reduces both yield and quality of the fibre. As the spores or reproducing bodies of the fungus are carried in large numbers by the wind, rust is difficult to control, but trials which have been carried out in other parts of the world have indicated that in a normal season the majority of crops are little affected. Stem breaking or browning is another fungus disease which attacks the plant through the cotyledons. The stem collapses close to soil level. This fungus is also responsible for the blight of leaves,

stems and bolls which appears shortly before harvesting. To this phase of the disease the name of browning is applied. Browning substantially lowers the quality of seed and fibre. In this State very little trouble should occur from these diseases as only a very small amount of linseed or linen flax has been grown previously. Also, the seed which has been used this season should have been relatively free from any of the above mentioned diseases. To assist in controlling any disease all the seed before it was forwarded to the farmers, was treated efficiently with Cerosan New.



An excellent crop of Linen Flax grown in New Zealand.
[Block by courtesy New Zealand Journal of Agriculture.]

Insect Pests.

The pests likely to prove a menace to flax production, are the red legged earth mite and cutworms.

The mite damages the crop in the early stages and causes a severe set-back and in some cases death of the plants. The best control is the preventive measure of clean fallowing for as long as possible before planting the crop.

Cutworms are controlled by the same cultural methods. The climbing cutworms, which attack the plants in the seed heads, are the most serious.

Further information on the control of these pests is contained in leaflets available at the Department of Agriculture.

Strains.

Much work has been carried out in Victoria to determine the most suitable strains for the production of linen flax in Australia. Up to date the strain most successfully used is the one known as Liral Crown, which gives high yields

of satisfactory straw. This strain is a relatively late maturing one. The Liral strains were developed by the Linen Institute Research Association in North Ireland. Other strains known as Stormont strains were developed by the Government in North Ireland, as superior strains of fibre flax. We have for instance, the Liral Monarch, Liral Dominion, Stormont Cirrus and Stormont Gossamer, these being all relatively new strains. The Blue Riga is one which has been grown in Australia for many years. The seed which has been sown this year in Western Australia is known as the Concurrent White Flowering Dutch strain, which is a late maturing one. There are many strains, ranging from early to late maturing groups.

Ploughing with mould-board plough on typical flax country, Gippsland.
[Block by courtesy Victorian Journal of Agriculture.]

Cultivation.

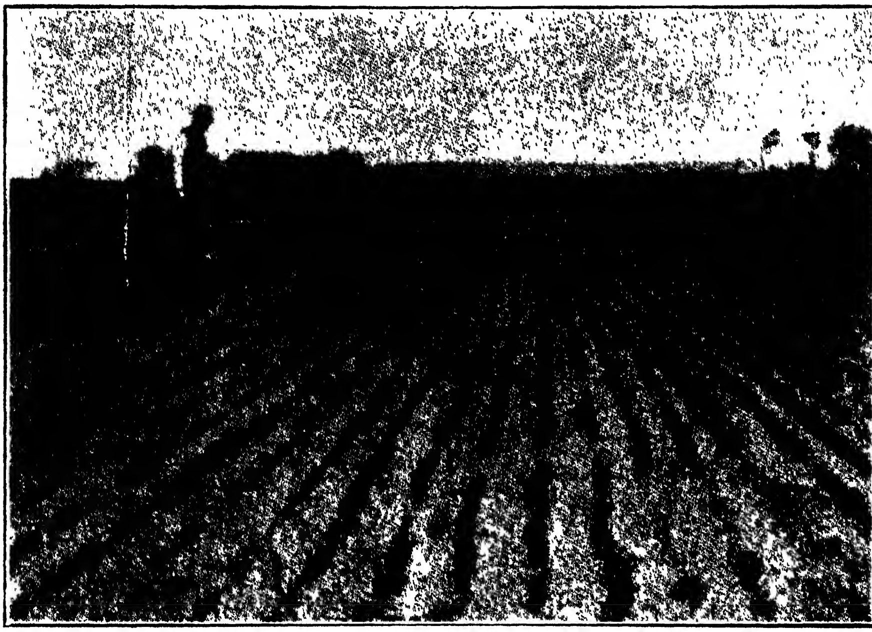
Owing to the seed being small, well worked, compact, fine seed-beds, free from weeds are necessary prior to planting. It is recommended that the land be ploughed to a depth of four to five inches with a good mould-board plough, which turns the sod completely over as shown in the accompanying block. The land should then be worked down with harrows and cultivators; if possible, rolling to compact the soil would be advisable to enable a fine, smooth seed-bed to be prepared for seeding operations. Prior to planting, it may be necessary to carry out further surface cultivation to control any weeds which may have appeared. It is usually recommended to have the land in fallow for a period of at least four weeks prior to seeding. This would also assist in controlling the red legged earth mite which attacks the young seedlings.

Rate of Seeding.

Experiments carried out in Victoria indicate that 50 lbs. per acre of seed is rather light, but that heavier sowings than 70 lbs. per acre are hardly necessary. In any case, where soil conditions are such that a good germination can be expected, sowing more than 70 lbs. per acre may be attended by the risk of crop lodging.

Time of Sowing.

Time of sowing trials carried out in Victoria have shown very interesting results. There is a general reduction in yield from the May to the September plantings, and very late sowings give extremely light yields. It is recommended for normal years that, under our conditions, May to June planting would be the most successful. Although late planting has been carried out this year, provision has been made for the bulk of the areas to receive irrigation water, if necessary, at the latter end of the growing season.



Block showing patchy germination of flax due to deep sowing and dry weather.

[Block by courtesy Victorian Journal of Agriculture.]

Method of Sowing.

The seed can be either drilled or broadcast. If drilled, Victorian results have shown that the best width between the drills is 3½ inches, but seven inches can be used with success. Generally speaking, drilling is preferred, but the seed can be mixed with the superphosphate just prior to sowing and broadcast or sown through a top-dresser. If drilling is carried out, the fine side of the grain box feed is used, but as drills vary considerably in their rate of sowing for the same seeding, the farmer is advised to test his machine thoroughly before commencing to seed. Shallow drilling is essential. On no account should seed be placed deeper than one inch. The tubes can be left in the hose or removed and the seed allowed to fall direct on the ground, to give the effect of broadcasting. Very light harrows should follow. The use of the roller prior to seeding will assist in securing shallow sowing, and also leave the land comparatively level for low cutting at harvest.

Fertiliser.

In Western Australia it is considered that the only fertiliser required would be superphosphate applied at the rate of approximately two cwts. per acre. Where, however, last year's potato land is being used, an application of not less than 1½ cwts. would be suitable. It has been found in Victoria, that on any rich soils where strong growth can be expected, it would be wise to reduce the rate of application even lower than that recommended, especially if the seed has been sown early. It is better to have a two-ton crop of standing flax than a 2½-ton crop lodged. Where late sowings on rich land have been carried out, the rate of dressing of superphosphate should be increased. In Victoria muriate of potash and sulphate of ammonia combined with superphosphate have been tried over the last three years without sufficient success to warrant or recommend their use. Following the sowing of the seed no other treatment is required during the growing period except to remove tall growing weeds such as thistles, docks, etc. This should be undertaken when the crop is four to six inches high. Once flax is two to three inches high it is not affected by heavy frosts.

Harvesting.

European harvesting practice consists of pulling the flax crop by hand or machine, this operation costing approximately £2 per acre. By this method the sheaves can be made up free from all weed, and lodged crops can be handled efficiently. The Australian practice to date has been to use the ordinary crop binder which does the work much more cheaply. However, it cannot avoid the

A 3½-ton crop of flax in the stook at Strathkellar, Victoria.
[Block by courtesy Victorian Journal of Agriculture.]

inclusion of tall weeds or make good sheaves from a lodged crop. This disadvantage does not assume serious proportions in normal crops. Flax is tough and offers considerable resistance to binder knives, consequently plain knife blades should be used and they should be kept thoroughly sharp. The seed heads are prone to become tangled, and difficulty is often experienced in separating the cut from the uncut straw unless a special divider is attached to the machine. The sheaves should be well butted and tied somewhat closer to the head than

the butt. It is recognised that flax is ready for harvesting when the stem has turned yellow from half to one-third the way up, and the bulk of the small stem leaves have dropped to the ground. If no moisture can be squeezed out of the bolls or seed heads, harvesting can then be started. The most advanced seed heads will probably contain ripe seed while that in the greenest bolls will be slightly milky. However, it will mature considerably in the stook, and should be ripe when the straw is carted. The sheaves should be built into long narrow stooks. Ten days there without rain is usually sufficient to complete ripening, and the straw should then be forwarded without delay to the mill.

Flax Mill.

It is usually considered that the requirements for a flax mill would be a minimum of 1,000 acres and a maximum of approximately 1,500 acres. It is also necessary to have the areas in which the flax is growing located in close proximity to the millsite. A radius of 20 miles would be the limit. The Commonwealth Supply Department proposes to erect and equip a mill capable of handling the material from the area which is under production this year. The essential requirements for the mill are a site where water can be obtained the year round, where the land is relatively dry to facilitate the handling of the material from the stacks during all periods of the year, and also, if possible, close proximity to a power line.

The erection of a mill in a district is quite a big consideration to that area, as normally there would be quite a number of hands employed, and the mill would be working full time the year round. When the straw is received at the factory, and after weighing and stacking, at a time convenient to the general economic management of the mill, the straw is deseeded by pushing the heads between revolving metal rollers, the seed being subsequently cleaned by winnowing. Usually, the chaff is sold for feed while the seed is retained for sowing, but when surplus seed is available this is sold for oil extraction and linseed meal. After deseeding the straw is ready for retting. Retting is the technical term given to the process by which the fibre is reduced to a stage at which it can be separated from the rest of the material comprising the stem.

The most notable achievement in recent years has been the perfecting of the new method of retting which only takes as many hours as previous methods took days. While primitive methods of treating the flax straw may be effective in countries where there are relatively low standards of living, experience over a long period of years, and the success achieved in the past few years, clearly demonstrate that only the best technique, and the most efficient organisation, both financial and industrial, will do in Australia. In modern practice retting is carried out in tanks in the presence of warm water; the process exploits the activity of various bacteria always associated with flax straw; these organisms cause the decomposition of the material which binds the fibre together. By this process retting can be accomplished in a comparatively short time, while the old process of water or dew retting required anything from six weeks or more. The processing in this State for the first year will not involve the water retting method but one of decortication. After retting the material which is still in sheaf form is then put out and dried. After drying it is taken direct to the breaking and scutching machine. The straw is first put through a series of fluted rollers called the breaker, which cracks up the woody portion of the stem leaving the fibres intact with the woody parts still hanging on them. The broken fragments called shives are then beaten off with revolving blades. The modern breaker and scutcher does the whole process rapidly and automatically.

Fertilisers – Amendments to Registrations.

Since the publication of the List of Registered Fertilisers in the December and March *Journals*, the following fertilisers have been amended as in the accompanying table:—

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N_2) as Nitrate.	Nitrogen (N_2) as Ammonia.	Nitrogen (N_2) as Blood and Bone.	Nitrogen (N_2) as Bone Dust	Phosphoric Acid (P_2O_5) as Water Sol	Phosphoric Acid (P_2O_5) as Citrate Sol.	Phosphoric Acid (P_2O_5) as Acid Sol.	Phosphoric Acid (P_2O_5) as Total.	Potash (K_2O) as Sulphate	Potash (K_2O) as Muriate	Cash Price per ton on Rail, Perth.
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Potato Manure "B"	12	Sickle	Cuming Smith & Mt. Lyell Farmers' Fertilisers, Ltd.		3·75			14 50	·35	·75	15·60	4 50		7 2 0*
Amended	12	do.	do. do		3 00			16·25	·50	1·00	17·75	2 40		
Potato Manure "C"	13	do.	do. do.		3·50			16 75	·40	1·10	18 25			5 16 0*
Amended	13	do.	do. do.		3·00			17·50	·50	1 00	19 00			
Potato Manure "E"	14	do.	do. do.		3 50			14 00	·30	·70	15·00	8·00		7 19 0*
Amended	14	do	do. do		3 00			15·00	·50	1·00	16 50	4 80		
Orchard Manure	19	do.	do. do.		2 00			15·75	·40	1 10	17·25		5·00	6 6 0*
Amended	19	do.	do. do.		2·05			17 00	50	2 00	19·50		2·50	
Special Mixture "K"	20	do.	do. do.		8·34			8 40	20	·40	9 00		10·04	10 2 6*
Amended	20	do.	do. do.		4 10			13 50	50	2·00	16 00		5·00	
Super and Ammonia, No. 1	22	do.	do. do		2·94			17 57	43	·85	18 85			5 10 6*
Amended	22	do.	do. do.		3·00			17 50	·50	1·00	19·00			
Potato Manure No. 2	40	ML in diamond	do. do.		3 50			16·75	·40	1 10	18·25			5 16 0*
Amended	40	do.	do. do.		3 00			17·50	·50	1·00	19·00			
Potato Manure No. 3	41	do.	do. do.		3 75			14 50	35	·75	15·60	4 50		7 2 0*
Amended	41	do.	do. do.		3·00			16·25	50	1·00	17·75	2·40		
Potato Manure No. 4	42	do.	do. do.		3·50			14·00	·30	·70	15 00	8·00		7 19 0*
Amended	42	do.	do. do.		3 00			15·00	50	1·00	16·50	4·80		
Orchard Manure	47	do.	do. do		2 00			15 75	·40	1·10	17·25		5·00	6 6 0*
Amended	47	do.	do. do.		2 05			17 00	50	2 00	19·50		2·50	
Special Mixture "K"	48	do.	do. do.		8 34			8·40	·20	·40	9·00		10·04	10 2 6*
Amended	48	do.	do. do.		4 10			13 50	·50	2 00	16 00		5·00	
Super and Ammonia, No. 1	50	do.	do. do.		2·94			17 75	43	·85	18·85			5 10 6*
Amended	50	do.	do. do.		3·00			17·50	·50	1 00	19·00			
Potato Manure "B"	68	CSML	do. do.		3 75			14·50	·35	·75	15·60	4·50		7 2 0*
Amended	68	do.	do. do.		3·00			16·25	·50	1·00	17·75	2·40		
Potato Manure "C"	69	do.	do. do.		3·50			16·75	·40	1·10	18·25			5 16 0*
Amended	69	do.	do. do.		3·00			17·50	·50	1·00	19 00			
Potato Manure "E"	70	do.	do. do.		3 50			14 00	·30	·70	15·00	8·00		7 19 0*
Amended	70	do.	do. do.		3·00			15·00	50	1 00	16·50	4 80		
Orchard Manure	79	do.	do. do.		2·00			15·75	·40	1 10	17·25		5·00	6 6 0*
Amended	79	do.	do do.		2 05			17 00	·50	2 00	19 50		2·50	

* On rail at Works.

FERTILISERS—AMENDMENTS TO REGISTRATIONS—*continued.*

Name of Fertiliser.	Reg. No	Brand	By Whom Registered	Nitrogen (N_2) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail, Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone Dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Special Mixture "K"	80	CSML	Cuming Smith & Mt. Lyell Farmers' Fertilisers, Ltd.		8.34			8.40	.20	.40	9.00		10.04	10 2 6*
Amended	80	do.	do. do.		4.10			13.50	.50	2.00	16.00		5.00	
Super and Ammonia, No. 1	82	do.	do. do.		2.94			17.57	.43	.85	18.85			5 10 6*
Amended	82	do	do. do.		3.00			17.50	.50	1.00	19.00			
Special Orchard Manure	103	Cresco	Cresco Fertilisers (W.A.), Ltd.		8.34			8.40	.20	.40	9.00		10.04	10 5 0
Amended	103	do.	do. do.		4.10			13.50	.50	2.00	16.00		5.00	
Potato Special	104	do.	do do.		4.00			12.70	.30	.70	13.70	9.00		8 10 6
Amended	104	do.	do do.		3.00			15.00	.50	1.00	16.50	4.80		
Batsos	142	Batsos	Batsos Trading Co				1.00	1.25	1.00	1.75	4.00	Trace	Trace	Price on application
Amended	142	do	do. do.				Trace	.24	1.00	.76	2.00	Trace	Trace	

* On rail at Works.

Fertilisers – Additional Registrations.

Since the publication of additional regulations in the March issue of the *Journal*, the following fertilisers have also been registered.

Name of Fertiliser.	Reg. No	Brand	By Whom Registered.	Nitrogen (N_2) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail, Perth.
				Nitrate.	Ammonia	Blood and Bone	Bone Dust	Water Sol	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
Blood and Bone	143	P over BB	Paton Burns & Co			5 25			8·0	4·0	12·0			6 12 6†
Do. do.	144	Wooltana	Modra Homann, Wooltana Fertilisers, Ltd.			6 0.)				11·5	11 5			9 5 6
Cockbill's Blood and Bone	145	Cockbill	J. Cockbill			5 25			3·0	9·0	12·0			11 10 0
Fall's Bone Fertiliser	146	Fall's	W. H. Logie & Son				3 0		6·0	15·0	21·0			8 10 0
No. 1	147	Wooltana	Modra Homann, Wooltana Fertilisers, Ltd.			4 0		1 37	92	9 2	11·31			8 17 0
Potato Manure, No. 1	148	Cresco	Cresco Fertilisers (W.A.), Ltd.		3 0			17·50	·50	1·00	19 00	..	..	7 5 6*
Do. No. 2	149	do.	do do.		3·0			16·25	·50	1·00	17·75	2·40		8 0 0*
Orchard Manure	150	do.	do do		2 05			17 00	·50	2·00	19·50		2·50	7 10 6*
Limax	151	Limax	Harris, Scarfe & Sandovers	Trace	Trace						Trace		Trace	10 0 0‡
Blood and Bone	152	Xlint	Barron Linton & Co			5 00			7·00	7·00	14·00			
Bone Dust	153	Albany Freezing Works, Ltd.	Albany Freezing Works, Ltd.				3 5			22·00	22·00			8 0 0

* On rail at Works. † F O.B. Sydney ‡ 45·6% Calcium oxide CaO (in the case of Agricultural Lime).

Dairy Farming and Pig Raising at Brunswick.

M. CULLITY, Senior Agricultural Adviser.

Brunswick is a township on the main Perth-Bunbury road, 100 miles from Perth. It is situated at the edge of the foothills of the Darling Range and its farming properties spread from these foothills, over the coastal plain.

During the past few years irrigation waters have been available and farmers have made great efforts to improve their paddocks with regard to their layout, size, surface, and pasture constituents, so that they could make use of the water most efficiently.

Dairy Production.

Dairy production in the district is marketed as whole milk, cheese milk or cream. The proportion of the total butterfat marketed as whole milk was 28 per cent. while very much the greater amount of the remainder was marketed as cream. For the whole milk trade a treatment plant is installed in the town of Brunswick, where also a cheese factory operates for a portion of the year only. Cream producers have the option of supplying either of two factories belonging to one company, which are situated approximately 15 miles away in different directions. Those desiring another market, forward their cream by rail to another company approximately 80 miles away.

A Herd Recording unit has been operating in the district since 1933 and the table hereunder shows that farmers have utilised the information which became available.

TABLE 1.

Year.	Number of Cows Tested.	Average Production Butter Fat. lbs.
1933–34	649	169·20
1934–35	615	206·00
1935–36	598	217·20
1936–37	623	231·32
1937–38	575	253·15
1938–39	654	284·37

The success achieved by farmers led them to a consideration of other methods of surveying farm results and some desired to see some measure of production made on the unit of one acre. This desire was the result of the feeling that high average production per cow did not necessarily indicate efficient farm management as distinct from herd management. Some information on this particular point is given later in this report.

It was with the object of meeting this expressed wish of the farmers that the local branch of the Primary Producers' Association and Messrs. Brownes Ltd., milk dealers and cheese manufacturers, made available trophies for the owners of the farms producing the greatest quantity of butterfat from each acre. There were two sections, one for irrigated and one for dry farms.

As farming operations in this area vary from dairying only to dairying combined with pig-raising, and fat lamb production, it was necessary to devise some means by which comparisons between farm and farm could be carried out. This was eventually arranged according to the following method.

A questionnaire was completed by each farmer. This disclosed the acreage of pasture of each property. It also gave details of the various classes of livestock. According to the scale given, hereunder, the number of livestock units on each property was calculated:—

TABLE 2.

One livestock unit is the equivalent of—

1 cow.
1 bull.
1 horse.
1 steer over 2 years.
2 steers over 1 and under 2 years.
1 heifer over 2 years.
2 heifers over 1 and under 2 years.
4 calves.
8 sheep.
14 lambs.

As a cow constitutes one live stock unit it was then a simple calculation to estimate the number of acres which would be used by the cows, assuming all types of stock received the same treatment regarding pasturage.

The actual production of butterfat from each farm was collected from factory statements, and allowances for calf feeding, and for consumption of milk, butter and cream in the home were made.

The total amount of butterfat so obtained was then divided by the number of acres utilised by the milking cows (cow-acres) and the result is stated as the production of the farm per acre. It was upon these figures that the competition was decided.

In table 3 are shown the results. Column A represents the basis as above, on which the competition was determined. Column B shows the production calculated on an area sufficient to run all the dairy stock held on each farm, while in Column C are the figures calculated on the full area of pasture on the farm.

TABLE 3.

Farmers.	Production per acre.		
	A. Acres used for Cows.	B. Acres used for Dairy Stock.	C. Total Pasture (acres).
Farm	Butter Fat lbs.	Butter Fat lbs.	Butter Fat lbs.
1	169·5	101·7	101·7
2	153·4	133·7	93·2
3	142·0	122·0	97·7
4	125·7	100·6	90·5
5	123·5	108·0	100·0
6	113·2	90·6	80·5
7	110·8	100·3	77·5
8	107·4	98·7	80·1
9	106·0	74·0	64·3
10	104·6	85·1	62·0
11	98·2	95·1	69·9
12	85·5	45·1	41·7
13	84·5	68·5	29·5
14	83·0	72·0	67·0
15	74·2	63·7	62·5
16	64·5	47.0	24.6
17	57.1	48.4	37.0

Where the figures in columns A and B are close it indicates that very few dairy stock other than milking cows are being held. Conversely where wide differences occur it can be accepted that there are a large number of dairy stock not yet in production.

High producing heifers.
[S. Bowers, Brunswick.]

As an instance of the former, the case of Farm No. 11 may be cited. Here the figures are 98.2 lbs. and 95.1 lbs. respectively. On this farm the average number of stock carried through the year was 71 cows, 6 heifers and 2 bulls, while as an example of the latter position, Farm 12 shows production of 85.5 lbs. and 45.1 lbs. respectively in these columns. This farm is still in the developmental stage and a large number of young stock are carried in order not only to replace culls, but also to increase the size of the herd. The actual number of the various classes of stock on this property was as follows:—

32 cows.
16 heifers over 2 years.
12 heifers—yearlings.
12 heifers—calves.
1 bull.

This farm had a low output of butterfat on a dairy stock acreage, but in a year or two when the herd has increased in size, the total production will increase rapidly.

Differences between columns B and C indicate the degree to which stock other than dairy cattle are carried. For example Farm No. 1 is stocked entirely with dairy cattle while Farm No. 2 is carrying many sheep.

Herd Replacement.

Table 4 indicates the position regarding disposals and purchases of cows and the numbers of heifers which freshened during the year.

In the seventeen herds there was an increase of five cows only. One hundred and thirty-one (131) cows were sold while new heifers calving and fresh purchases amounted to one hundred and thirty-six (136).

The causes of the disposals may be taken as being similar to those pertaining for the year 1939-40 in the Grade Herd Recording Unit for the district.

TABLE 4.

Farm.	Number of Cows in Herd.	Number of Cows Sold during Year.	Number of Cows Bought during Year.	No. of Heifers.			
				Freshened.	Over 2 Years.	Between 1 and 2 Years.	Under 1 Year.
1 ...	21	7	7	4	5	5	14
2 ...	62	3	...	...	...	7	9
3 ...	24	8	1	2	...	4	4
4 ...	19	3	3	...	...	4	3
5 ...	60	...	22	15	...	5	6
6 ...	55	9	...	7	1	11	21
7 ...	19	...	...	3	...	...	5
8 ...	48	5	...	11	...	7	22
9 ...	42	11	...	...	11	18	8
10 ...	36	6	3	7	...	11	10
11 ...	71	19	8	15	...	6	3
12 ...	32	...	...	...	16	12	13
13 ...	84	29	...	8	5	9	26
14 ...	87	7	...	12	...	12	27
15 ...	32	6	...	...	...	5	6
16 ...	41	12	2	6	8	15	9
17 ...	50	6	...	...	6	8	10
	783	131	46	90	52	139	196

Six hundred and thirty-five (635) cows were recorded, and one hundred and six (106) were culled.

The causes for culling were as follows:—

Low production	72	68% of culls.
Old age	3	2.8% of culls.
Failure to breed	5	4.7% of culls.
Faulty and diseased udders	14	12.2% of culls.
Contagious abortion	3	2.8% of culls.
Surplus stock	2	1.8% of culls.
Milk fever (deaths)	7	6.6% of culls.
Total	106	16.7% of culls.

Of the one hundred and thirty-six (136) replacements ninety (90) only were heifers reared on the farms where they calved. This means that only two thirds (2/3rds) of the replacement stock were held on the farms in that year.

From the foregoing, it appears that heifers to the number of seventeen per cent. (17%) of the number of cows in each herd should have been held on the farms for replacement purposes. Where development of the properties for dairying is still in progress, a greater proportion of heifers would be required.

An examination of the position in the herds at the moment with reference to future requirements indicates that sufficient young stock are available in the district. Actually the number of heifers over one year of age and of those under one year amount to twenty-three and twenty-five per cent. respectively of the number of cows. But a closer perusal of the position as disclosed by Table 4 shows that while a number of farmers are breeding sufficient heifers for replacement and

development, others are relying on purchases to remedy the position. For example Farm No. 5 has heifers to the amount of 8½ per cent. only of the herd size. In the previous year, thirty-seven per cent. (37%) of the herd was purchased.

Farm No. 11 had the following record during the year. Nineteen cows were sold, eight cows were purchased and fifteen heifers calved, bringing the herd up to seventy-one (71) cows. At that time heifers to the number of 8 per cent. of the herd size for the 1939 season and 4 per cent. for the 1940 season were available for replacement purposes.

It follows that this farmer must go to the saleyard to obtain his requirements of replacement stock. This put him in the very great danger of bringing disease into the herd, which would more than counter-balance any advantage gained during a few years by stocking the farm with the maximum number of cows. There is no necessity to place any greater emphasis than this on the financial loss that results from the introduction of contagious abortion, infectious mammitis, etc., into a dairy herd.

Apart from a consideration of the foregoing it is interesting to note that the quality of some at least, of the heifers in this district are very satisfactory. The bulls in use are practically without exception pure bred, and the effect of the emphasis placed on the necessity for production backing for the bulls and more recently on "proved bulls," is shown in the quality of the young stock.

The following figures are taken from the annual report of the unit as furnished by the Recorder (Mr. S. A. Hardy). The unit average was 283 lbs. butterfat. The mature cows tested produced 308 lbs. each while the 3 and 2 year old heifers had figures of 306 lbs. and 292 lbs. respectively (adjusted to a mature cow basis). This indicates that the quality of the young stock is certainly not falling but is in fact higher than mature cow averages in most other units.

Among the various factors focussing attention on quality in heifers, is a trophy awarded each year to the owner of the four highest producing heifers in any one herd in the unit. This is the S. A. Mitchell Cup. The average productions for the winning team and for the past four years, are as follows:—

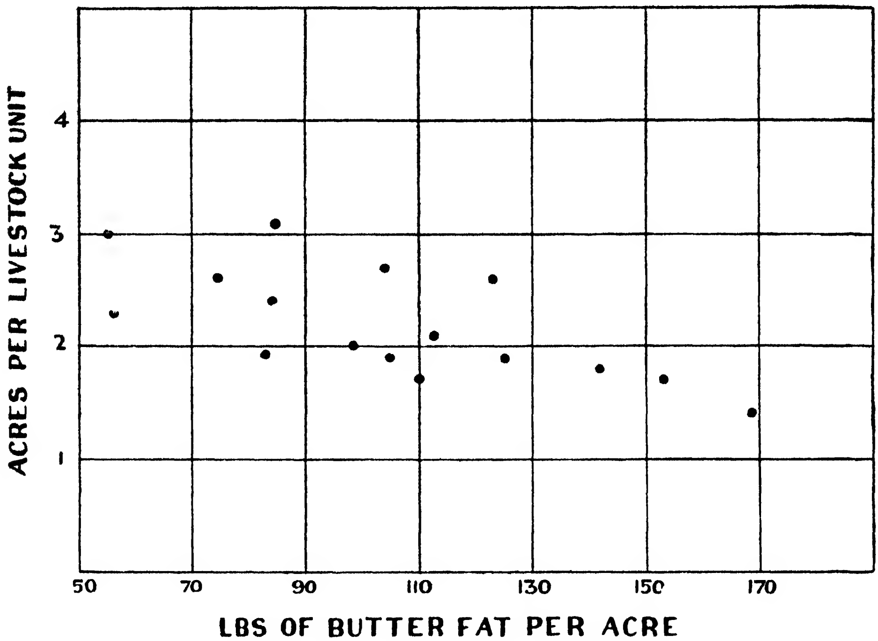
1936-37	342 lbs. butterfat.
1937-38	326 lbs. butterfat.
1938-39	337 lbs. butterfat.
1939-40	396 lbs. butterfat.

Naturally each year the trophy is won by a different team, and in the four years, the teams represent three different herds.

Carrying Capacity.

This is one of the problems of the dairy farmer to decide just what degree of stock concentration will give the greatest total output. It is axiomatic that the concentration of stock must not go beyond the limits where a sufficiency of fodder is available to give high individual production per cow. Beyond this stage the farm becomes overstocked and there is insufficient feed available above the maintenance requirements of the herd, to provide the nutrients for free milk production.

In this competition it is demonstrated that the area used per cow unit was much less than that normally considered necessary. In the final Better Dairying Competition concluded in 1936, it was shown that the average area required per "cow unit" was 4.25 acres, while approximately 3 acres were required per live stock unit.



RELATIONSHIP OF STOCKING CONCENTRATION AND PRODUCTION PER ACRE

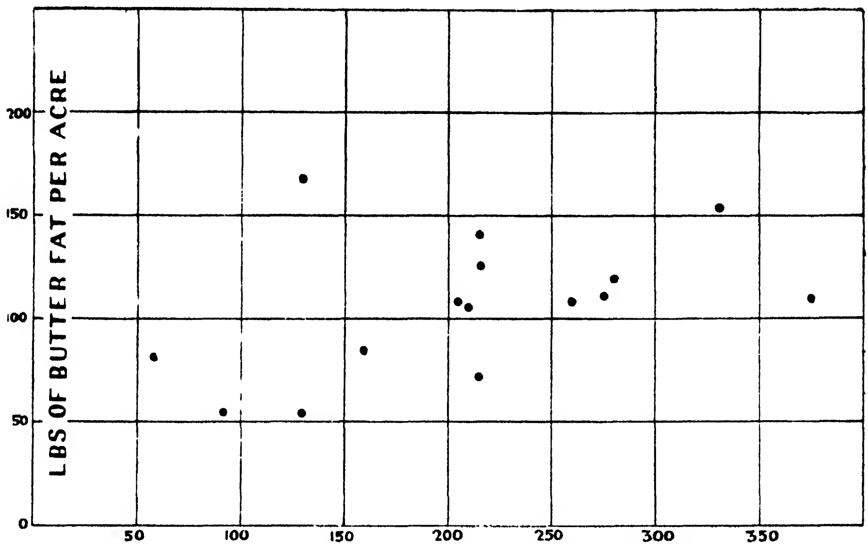
Results on this occasion, however, indicate that 2.8 acres only were needed per cow unit and 2.3 acres per live stock unit.

In the case of the leading farms the position was as follows:—

Type of Farm.	Farm Number.	Acres per—	
		Cow Unit.	Live Stock Unit
Irrigated	1	2·4	1·43
	2	2·0	1·72
	3	2·7	1·80
Dry Farm	9	2·9	1·90

Block A shows that there appears to be some correlation between stocking concentration and production per acre, but insufficient evidence is available to permit of any suggestion regarding the optimum degree of stocking. This obviously would vary according to the proportion of irrigated land, the quantity of fertiliser applied, the number and size of the paddocks, and many other factors.

That there also appears to be a definite relationship between the quantity of superphosphate used per acre and the stocking concentration is shown by Block B.



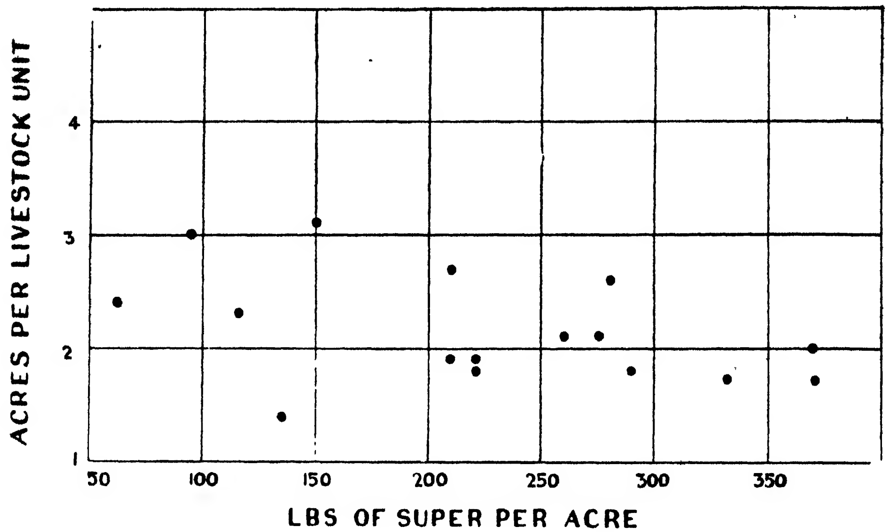
RELATIONSHIP OF RATE OF SUPERPHOSPHATE APPLICATIONS AND PRODUCTION PER ACRE

In Block C it will be noted that the highest return per acre was obtained with a small application of super. In seeking for an explanation of this, the following information was obtained which probably explains, in part at least, why such results were possible.

The property in question is portion of the homestead section of the former Brunswick State Farm. It surrounds the site of the stables and cow sheds. It was stated that this area was particularly heavily fertilised over a period of years with artificial manures of various types. In addition, the dung and refuse from the stables and bails were regularly spread over the paddocks. Since the occupancy of the present owner, no fire has been allowed to clean up dry grass in the paddocks so that the soil has had its supply of organic matter considerably increased. Whether the property is now in the state that it will continue for some time to give high yields with small applications of manure, it is impossible to say.

The general conclusion which may be drawn from Block C, however, is that high production has followed high rates of application of super. That there is a considerable margin of profit in the higher dressings can be proved by a single calculation from the data in the block.

It is considered that there is evidence in this block as to how farmers may increase the turnover from their properties. This evidence is amply supported by numerous cases in other districts where increased production has followed increases in the rate of applications of superphosphate.



RELATIONSHIP OF RATE OF SUPERPHOSPHATE APPLICATIONS AND CARRYING CAPACITY.

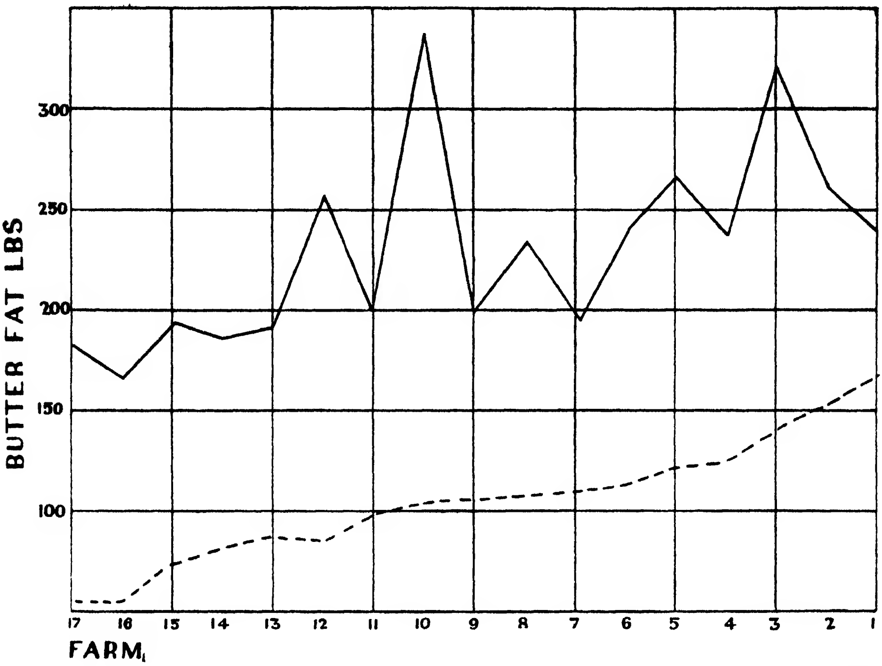
Production per Cow v. Production per Acre.

The comments made at the conclusion of the preceding section should not be read to mean that an increased application of superphosphate in itself, without any further effort on the part of the farmer, will return added production. It is necessary to make such provision that it will be possible for stock to utilise the additional feed produced economically, i.e., by adequate subdivision, watering facilities and the adoption of a proper system of controlled grazing. The references to the relationship between superphosphate applications and stocking concentration does not infer that a farmer can order an extra ton of superphosphate and an extra cow at the same time. A warning must be given against the disaster that can follow overstocking.

It can be shown that the way to increased production per acre is through increased production by each individual of the herd. Naturally with a certain herd size the higher the production per cow the higher the total production; farmers must not be led astray in discussing this matter by the occasional references to cases where increased production per cow has been achieved by a reduction in the number of the cows.

Block D shows a comparison between the production per acre and production per cow for the 17 farms. It will be noted that the general trend of production per cow is upward, while production per acre is increasing. It is interesting to investigate the high peaks in the curve for production per cow. The herd on farm 10 averaged 343 lbs. butterfat for 36 cows. The stocking concentration, however, was very low, 3.7 acres being utilised per cow unit, and 2.7 acres per live stock unit. Approximately 145 acres of pasture were available, 1.25 tons of hay per cow were conserved in addition to there being 22 acres of summer irrigation

and 18 acres of winter pasture started by irrigation water. On comparison with the other properties it appears as if more stock could profitably be run on this property.



COMPARISON OF PRODUCTION STATED AS PER ACRE, AND AS PER COW

BUTTER FAT PER ACRE ------
PER COW ———

On farm 12 also the stocking concentration is light because the property is still in the development stage and the herd is being built up wisely by breeding heifers. In this case 3.1 acres per live stock unit and 3.4 acres per cow unit were available.

On Farm 3 stocking was heavier, 1.7 acres per live stock unit being available.

Irrigation.

Comparison between irrigated and non-irrigated properties is given in Table 5.

Unfortunately there were only a few properties where irrigation was not being practised to some extent at least and therefore the comparison cannot be considered as complete.

Six farms had more than 40% of the cow acres irrigated and these averaged 127 lbs. of butterfat per acre.

Seven farms, excluding the non-irrigated properties, had less than 40% of the cow acres irrigated and averaged 106 lbs. of butterfat per acre.

TABLE 5.

Irrigated Farms.		Tons Hay Cow.	Non-irrigated Farms.		Tons Hay Cow.
Name.	Butter Fat lbs. per acre.		Name.	Butter Fat lbs. per acre.	
R. C. W. Smith ...	169·5	·75	S. A. Mitchell ...	106·0	·30
Farm No. 2 ...	153·4	·50	Farm No. 16 ...	64·5	·20
Do. 3 ...	142·0	...	do. 17 ...	57·1	·12
Do. 4 ...	125·7	·166			
Do. 5 ...	123·5	·66			
Do. 6 ...	113·2	·6			
Do. 7 ...	110·8	1·0			
Do. 8 ...	107·4	...			
Do. 10 ...	104·6	1·25			
Do. 11 ...	98·2	...			
Do. 12 ...	85·1	·62			
Do. 13 ...	84·5	·18			
Do. 14 ...	83·0	·9			
Do. 15 ...	74·2	...			

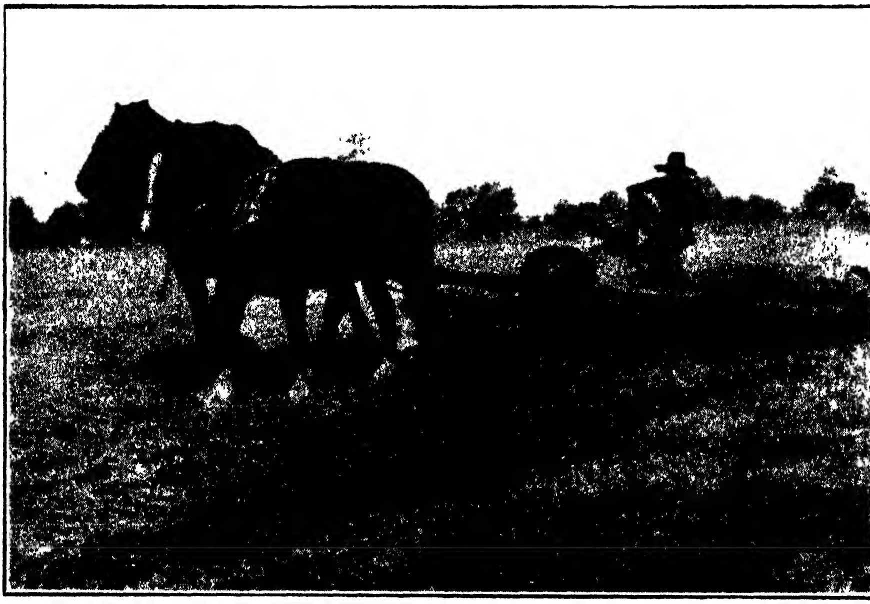
Conservation of Fodder.

The amount of fodder conserved per cow is shown in Table 5. It will be noted that the quantities are very small, the greatest being 1.25 tons per cow.

It is popularly assumed among these farmers that summer irrigation, followed by starting the winter pasture with irrigation water, obviates the necessity for conserving any great quantity of fodder. This is because green feed is available during the summer months and the winter pastures have made growth when

In the Brunswick hill country. Raking clover burr by hand.

watered early, before the summer pastures lose their usefulness. Naturally there is some point in this argument, but unfortunately several factors still operate which make sole reliance on the pasture extremely dangerous. For example, in many cases it is doubtful whether sufficient growth can be obtained from the relatively small areas of irrigated pasture to adequately feed the herd. Again the growth of the winter pastures slackens and becomes almost dormant during the wet cold months of June and July, and ample hand feeding is then required.



Home-made rotary broom for sweeping clover burr.

The position at this period is considerably worse when a rainfall above average is encountered. The winter pastures are then so sodden that little effective use can be made of them.

This actually proved the case during the 1939 season, when the supplies of fodder conserved during the 1938 harvest were utilised. The effect of this deficiency of feed is shown in the results of the Grade Herd Recording Unit for 1939-40

Normally the production of cows which complete a full 273 days' test is considerably higher than those which do not complete this period. This seems obvious. But in the Brunswick unit in 1939-40, the cows which completed 273 days did not produce more than those which were not tested for the full period. The bulk of the former group calved in May and June.

TABLE 6.

——	Cows Completing 273 days.		Unit Average.
	Per cent.	Butter Fat Average—lbs.	
1938–39	62·7	293·84	284·37
1939–40	72·0	250·74	251·88

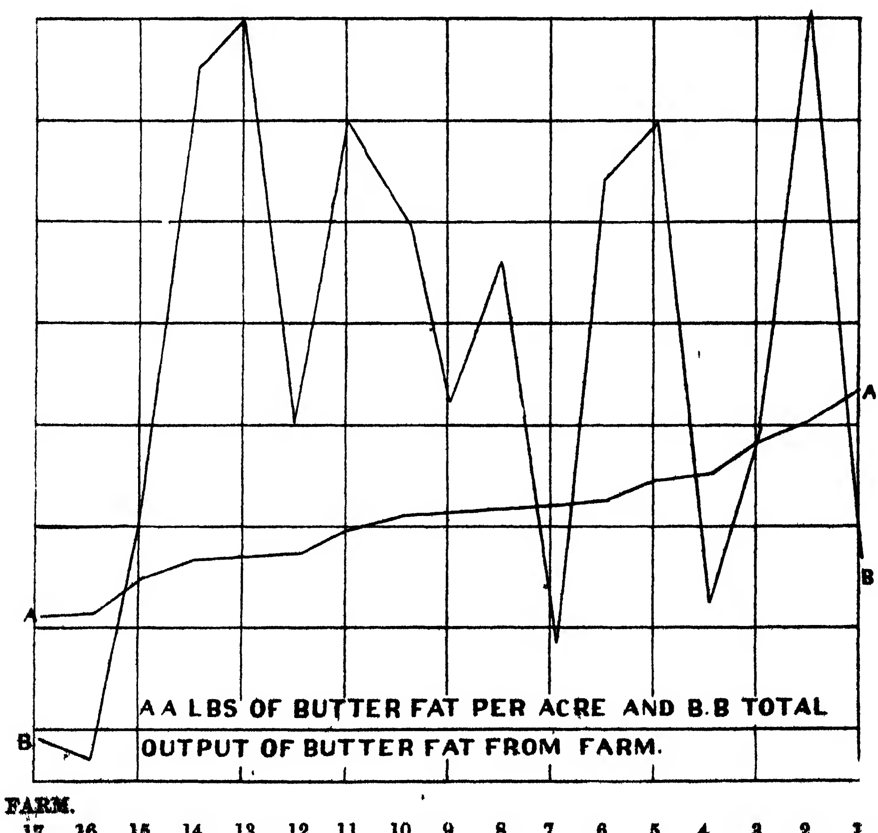
That the absence of sufficient fodder for the cows calving in May and June was responsible for the low production is indicated in Table 7.

TABLE 7.

Averages of Cows Calving in May and June, 1939.

	May.		June.	
	No. of Cows.	Average.	No. of Cows.	Average.
Hay Available	43	265	30	269
No Hay Available	64	214	51	237

It is hoped that as a consequence of this position, farmers will make adequate reserves during the coming season. It is suggested that the conservation of 1.5 tons of hay per cow should be the aim where ample irrigated pasture is available and the equivalent of 2½ tons per cow as hay, silage or green crops where no summer grazing is possible.



Total Output and Production per Acre.

As expected there is no relationship between the total output of butterfat from the farms and their average production per unit of area. The size of the properties varied over wide limits and in some cases more than offset the effect of the relatively low unit production.

The fact that there is no connection between total output and average per acre answers the criticism that high production per acre is more likely on the smaller properties which would therefore command an advantage in a comparison of this kind.

To illustrate this point, attention is directed to the fact that the four properties producing the greatest quantities of butterfat are placed second, thirteenth, fifth and fourteenth in the order of their production per acre. Actually the property which produced the greatest amount of butterfat had the second highest average per acre.

In block D is shown a comparison between the total figure and the average.

The natural corollary of this position, of course, is that by increasing the production per acre, no matter what size the farm may be, the total output will be increased, and under normal conditions allow a greater margin of profit to the farmer.

Method of Milking.

It is interesting to record that on the leading four farms, the herds are milked by hand labour. On all the others, with the exception of two (2), machines are in use. Of the 11 machines in use, seven were of the one type.

It has been been suggested that the labour, usually family labour which was available on the leading farms, contributed to the higher production. This suggestion was developed with the thought that the labour would be available for other work on the property such as fencing, clearing, irrigation, conservation of fodder, etc., thereby allowing the owner more time to devote to a plan of development and increased carrying capacity. No evidence was collected to confirm or disprove this argument.

A comparison of the number of cows milked by hand labour and machine showed that there was little difference between the average numbers per man and per unit. The figures were 9.25 and 12.5, respectively.

The advantage of the machines, however, becomes obvious when the number of cows attended per man is calculated. Over the eleven properties 24 cows were attended in the milking shed per man.

One conclusion which may safely be drawn from this is that there is still ample capacity for development in the size of the herds where machines are in use before it will be necessary to procure larger machines.

The only additional cost for some time, as the herds increase in size, would be on account of longer periods of operation. Usually machines have sufficient reserve power and vacuum pump capacity to allow extra units to be added without requiring other changes.

Pig Raising.

Table 8 shows the position regarding the production of pigs. It has been considered convenient to give this in terms of the pounds of pig meat produced per 100 pounds of butterfat. The figures are not the result of weighing the pigs individually but have been calculated according to the number and type of pig sold.

Only five farmers kept sows and the cow to sow ratio is shown for each of these properties. It varies from 12.5 : 1 to 4.2 : 1. It will be seen that the average production of pig meat per 100 lbs. of butterfat produced as cream from these farms was 60 lbs. Where store pigs were purchased and fattened an average of 45 lbs. was produced. It is possible that by buying stores a farmer may produce as much pig meat as if he had a number of brood sows, but the above shows that in actual practice he does not. Actually it may be considered that the farmers whose results are being discussed have produced more pigs than appears to be the case in an equivalent group of farmers in other districts. This it is considered shows that they are fully alive to the opportunities for increased revenue which the pig industry offers. Therefore the evidence which is given herein showing a greater production of pigs from the properties where the pigs are bred should move them into acquiring sows.

There are probably a variety of reasons why the farmer buying stores does not make the same turnover. Possibly pigs are hard to get when he requires them or the price may be too high. Further, to show the same amount of pig meat actually grown on the properties it is necessary for him to handle a greater number of pigs.

It follows then that to keep a supply of good pigs available for fattening, the only sure way is to breed them. A further reason for doing this is that the risk of the pigs contracting disease is greatly reduced if no purchases in the ordinary market are made.

TABLE 8.

Farm No.	Cows.	Sows.	Sow : Cow Ratio. 1 :	Store Pigs Purchased.	Lbs. Pig Meat Sold per 100 lbs. Butter Fat.
16	41	5	8·2	45	107
9	42	10	4·2	...	94
6	55	5	11·0	...	58
13	84	10	8·4	...	36
17	50	4	12·5	...	35
7	19	...	...	30	65
8	48	...	...	100	54
10	36	...	...	27	30
3	24	..	...	50	27·2
4	19	...	...	26	26
12	32	...	...	44	17
11	71	...	...	8	7

A study of Table 9 also gives much information on the results that can be achieved by utilising skim milk efficiently, that is, by feeding it with cereal grains and other farm produced materials which not only enable more pigs to be fed but keeps the cost of feeding to a low figure.

Farm 9 had a sow:cow ratio of 4.2:1 and produced 94 lbs. of pig meat per 100 lbs. of butterfat. Actually this farm with a herd of 42 cows was able to return the owner more than £200 profit over the cost of purchased feeds. Wheat and pollard were purchased and crops of pumpkins and peas were grown.

Farm 16 had 5 sows but 45 store pigs were also purchased because a good supply of maize grain was on hand. The sow : cow ratio when the purchase of store pigs was taken into account is lower than 8.2 : 1. Had sows produced the

pigs on the property the ratio would have been 4.5 : 1. The cost of the maize grain was low and the margin of profit on the total number of pigs was very satisfactory.

Table 9 gives some idea of the returns obtained from pigs when expressed as an equivalent of butterfat per acre.

TABLE 9.

Return from Pig Meat at 6d. per lb. calculated as equivalent of Butter Fat per acre, Butter Fat at 1s. 3d. per lb.

Farm No.	Pig Meat per acre at 6d. per lb.	Lbs. Butter Fat at 1s. 3d. per lb.	Butter Fat per acre.	Total Cream and Pigs as Butter Fat per acre.
1	...	...	169·5	169·5
2	...	...	153·4	153·4
3	13/6	17·6	142·0	159·6
4	16/6	13·0	125·0	138·0
5	...	...	123·5	123·5
6	33/-	26·0	113·2	139·2
7	36/-	29·0	110·8	139·8
8	27/-	22·0	107·4	129·4
9	49/6	40·0	106·0	146·0
10	15/-	12·0	104·6	116·6
11	3/6	3·0	98·2	102·2
12	7/-	6·0	85·1	91·1
13	15/6	13·0	84·5	97·5
14	...	...	83·0	83·0
15	0/6	0·5	74·2	74·7
16	30/-	24·0	56·2	80·2
17	10/-	8·0	55·3	63·3

Egg Laying Trials—Muresk Agricultural College. 1939-40.

G. D. SHAW, Poultry Adviser.

The 1939-40 trial is the fifth of the second series conducted at Muresk Agricultural College. Seven previous trials were held prior to 1936, but a break occurred in the years 1933-35.

The duration of the trial is 48 weeks, beginning on the 16th March, 1939, and ending on the 1st February, 1940.

The trial for the year 1940-41 began on the 21st March and will continue until the 14th February, 1941.

A total of 336 birds were entered for the 1939-40 trial, being composed of:—Australorps 150, white leghorns 144, brown leghorns 6, Rhode Island reds 36.

Management.

The management of the trial is in the hands of a committee which consists of the Principal of the College (Mr. W. Southern), Chairman, the Poultry Adviser of the Department of Agriculture, Mr. G. D. Shaw; the Assistant Poultry Adviser, Mr. E. Lovegrove; Mr. S. Dolman, Cranleigh Poultry Farm, Welshpool; Mr. F. Landquist, York, and Mr. R. Knight, Kenwick.

The committee of management meet at the college periodically and directs the policy of the trial.

There are 336 pens available, and all birds are single tested. All eggs are weighed daily and the scales used are tested and graduated to one-tenth of an ounce.

The college is situated 60 miles from Perth. The soil is ideal and plenty of green feed is available in all seasons of the year. In the height of summer all the pens are shaded with a luxuriant growth of foliage from cape lilacs which have been planted between the rows.

The rules of the 1939-40 trial were as follow:—

Committee of Management.

The committee of management shall consist of the Principal of the College, the Poultry Adviser, Assistant Poultry Adviser, Department of Agriculture, or officers acting in their stead, and three representatives elected by the breeders taking part in the preceding trial.

Note.—The term "breeder" is given to those who have entered birds in the trials.

Powers of the Committee.

The committee shall have absolute control of the trials conducted during its tenure of office.

It shall recommend what tests are to be carried out and arrange the conditions and regulations governing the same. It shall also receive applications and allot the pens for the next trial.

The representatives elected shall take office on 16th March succeeding the date of appointment.

The committee shall meet at such times as it may deem necessary.

Trial for 1939-1940.

The trial shall consist of the following sections:—

Section "A"—Pen of six birds—All light breeds.
Section "B"—Pen of six birds—All heavy breeds.
Section "C"—Pen of six birds—All medium heavy breeds.

The trial shall extend from 16th March, 1939, until 14th February, 1940 (48 weeks). The leading group or individual bird in each section may be allowed to remain at the college for the full period of twelve months.

Each breeder shall be charged an entrance fee of 5s. per bird, 2s. 6d. per bird to accompany application for pens. The balance of 2s. 6d. per bird is to be forwarded to the Principal, Muresk Agricultural College, within 14 days after notice of allotment of pens; otherwise pens may be allotted to other applicants and the 2s. 6d. application fee forfeited.

For any of the above sections pure-bred birds only must be entered.

All eggs shall be the property of the Muresk Agricultural College.

Each of the pullets will be single tested, housed (semi-intensive), and the individual numbers and weight of eggs will be kept.

Regulations.

1. In each section the trial will be decided by the highest number of first grade eggs obtained by each group of birds and by each individual bird in their respective sections.

2. Sections "A," "B," "C":—During the first two months of the trial a first grade egg shall weigh not less than 1¾ ozs., thereafter during the remainder of the trial a first grade egg shall weigh not less than 2 ozs.

Second Grade:—The minimum weight of a second grade egg shall be not more than ¼ oz. less than a first grade egg. Second grade eggs will be recorded but not counted.

3. Eggs under 1½ ozs. in weight during the first two months of the trial and under 1¾ ozs. in weight during the remainder of the trial, soft shelled, or broken will be recorded, but not counted in trial results.

4. In all sections the actual weight of each egg shall be kept.

5. The certificate for the winter test, 16th March to 31st July, 1939, shall be given subject to rules 2 and 3.

6. Progress results will be published weekly as far as practicable, and all prizes shall be awarded as soon as possible after the termination of the trial. Results to be reported under breed headings.

7. No protest shall be considered unless received within 14 days of the alleged breach of regulations, and accompanied with a deposit of £1, which deposit shall be returned if the protest is upheld, or forfeited if, after inquiry, the protest is considered to be frivolous or without foundation.

8. Records shall be kept of the average cost per head of food consumed.

9. All birds to be accepted must conform to the following conditions:—

(a) Shall be the property of the breeder;

(b) Must be not less than six months and not more than nine months of age on 16th March, 1939;

(c) Must be fair specimens of the breed;

(d) Must weigh not less than:—

	lbs.
Section "A"—Light Breeds:	
Leghorn, Ancona	3¾
Minorca	4
Section "B"—Heavy Breeds:	
Australorp	5
Sussex, Langshan	5
Plymouth Rock	5
Section "C"—Medium Heavy Breeds:	
Barnevelder	5
Rhode Island Red	5
Wellsummer	4½
Wyandotte	4½

10. All birds sent to the trial must conform with the weight prescribed in the preceding paragraph, otherwise the committee shall cancel the allotment of pens, in addition to which the entrance fee may be forfeited.

11. All birds shall be treated for vermin and delivered at the Muresk Agricultural College, Muresk, between 13th March and 15th March, inclusive, in new coops or crates, with the breeder's name and address clearly stencilled or painted thereon. Entries will not be accepted from any person whose premises are tick-infested or whose flock is suffering from any infectious or contagious disease.

NOTE.—No birds will be accepted on Sunday, 12th March, 1939.

12. Freight to the College is to be prepaid or delivery will not be accepted. Freight on rejected birds must be paid by the breeder.

13. All birds must be ringed with the numbered leg bands supplied and forwarded free to the breeder. These will correspond with the number of the pens allotted. The pens having overhead netting, it is unnecessary to cut any bird's wing feathers.

14. The Poultry Adviser, or his representative, shall have the power to reject any bird which in his opinion is not of the correct age, or which he considers does not conform in any way to Rule 9, and his decision shall be final.

15. Any bird found to be suffering from an infectious or contagious disease, or with crooked breasts, or side sprigs in combs, will be rejected and returned, and shall be replaced by a suitable one within seven days after the notification of same. If any bird is found infested with tick the group will be rejected, the entry cancelled, and the entry fee forfeited.

16. In the event of a bird during the course of the trial becoming diseased, incapacitated from laying, or developing vicious habits (such as egg-eating or feather-eating) it may be returned, or, on the written authority of the owner, destroyed.

Should this occur, the breeder may replace it with another bird of the same age and breed; in the case of a bird dying, replacement may be made. Any score standing to the credit of a bird which is replaced shall be struck out.

17. No breeder shall withdraw any bird until the termination of the trial, except as provided in Rule 16.

18. The committee reserves to itself the right to inspect, or to have inspected, any applicant's stock, with a view to determining whether the quality and character of the birds warrant the allotment of pens.

19 (a). Any breeder taking part in the current trial will have the right of allotment of one pen of six birds per section in the succeeding trial. After such allotment new applicants will have the right of allotment of one pen of six birds per section. Should there then be any vacant pens they will be allotted by ballot to any applicant.

19 (b). If after the allotment of pens, it is ascertained that incorrect information has been furnished the allotment may be cancelled and the birds returned. In such case the entrance fee shall be forfeited and the applicant may be debarred from entry to any future trial.

20. Any breeder violating or failing to conform to these regulations shall be subject to such disqualification as the committee may decide.

21. Where there is a tie for any place, the award shall be given to the breeder whose bird or group (as the case may be) lays the greater total weight of first-grade eggs.

22. While every care will be taken, the committee will not be responsible for loss or injury to any birds in any way in connection with the trial.

23. The committee may disqualify any breeder and may refuse entry to subsequent trials, where such breeder publishes in any way statements of records not in accordance with the official records of the trials.

24. The committee's decision in all matters shall be final.

PRIZES.

NOTE:

Certificates will accompany all prizes.

No prize shall be awarded in any section unless there are at least three entries. No second prize will be awarded unless there are at least four entries.

The full schedule of prizes will be published at an early date.

CHAMPION CERTIFICATE.

A Champion Certificate will be awarded to the group pen from sections "A," "B" and "C" obtaining the highest total of first-grade eggs during the term of the trial.

GOVERNMENT STANDARD CERTIFICATE.

A Government Standard Certificate and a Registered Sealed Copper Ring will be awarded to all birds laying not less than 200 two-ounce eggs or over during the term of the trial.

DISCUSSION.

Some explanation with reference to the classes may not be out of place. In the schedule it will be noticed that light, heavy, and medium-heavy classes are defined by weight. This is not a clear interpretation of the classes. It has been found that the activity of the different breeds varies, so much so that the feeding of light birds must be on a different plane to the feed given to the heavy. It was found that the food giving the best results for light breeds was too fattening for the heavy breeds. This was because the heavy breeds were not as active as the light and therefore did not utilise the carbohydrates to the best advantage. Hence the heavy breeds are fed on a narrower ration than are the light breeds.

Again, the breeds placed into what is described as medium-heavy, are not necessarily lighter in weight than are the heavy breeds, but those placed in the medium-heavy class are more active than those breeds placed in the heavy class, yet not as active as those of the light breeds quoted. Hence the rations suitable for the medium-heavy breeds should be wider than that given for the heavy breeds but narrower than that given to the light breeds. This has been satisfactory and the feeding at the laying trial is based on the article on "Feeding" published in the Journal of Agriculture, September, 1934, pages 435 onwards, and in the December, 1936 Journal, pages 465 onwards. This system of feeding allows the birds the necessary requirements of protein and carbohydrates consistent with their activities, and the noticeable factor at the completion of each trial of the second series has been that the birds have been returned to their owners in good condition, each bird having put on weight during the period, but no bird has carried superfluous fat.

The following are the results of the trial ending 14th February, 1940:—

SUMMARY

	Score.
Champion Certificate.	
N. T. Wilkinson: Australorps—	
1st grade eggs	1,256
2nd grade eggs	62
Section A—Team of 6 birds—Light breed.	
1st (Westfarmers' Cup) Mrs. M. H. Dadley –	
1st grade eggs	1,097
2nd grade eggs	3
2nd (Wright & Co. Trophy): Webb's Hatchery—	
1st grade eggs	1,075
2nd grade eggs	158
Section B—Team of 6 birds—Heavy breed.	
1st (W.A. Produce Market Cup) N. T. Wilkinson—	
1st grade eggs	1,256
2nd grade eggs	62

SUMMARY—*continued.*

Section B (*continued*):—

	Score.
2nd (R. Young Trophy) R. Harrison—	
1st grade eggs	1,231
2nd grade eggs	19
Section C—Team of 6 birds—Medium-heavy breed.	
1st (Ian Hazlett Cup) Robinson Bros.—	
1st grade eggs	990
2nd grade eggs	76
2nd (Kirkby Trophy) Cranleigh Poultry Farm—	
1st grade eggs	954
2nd grade eggs	10

Winter Test.—(from 16th March to 31st July, 1939).

Team of 6 birds—Light breeds.	
1st only (Philip Giles Trophy) Mrs. M. H. Dadley—	
1st grade eggs	480
2nd grade eggs	1
Team of 6 birds—Heavy breeds.	
1st only (Carbarns Trophy) R. Harrison—	
1st grade eggs	471
2nd grade eggs	12
Team of 6 birds—Medium-heavy breeds.	
1st only (Carbarns Trophy) Beverley Poultry Farm—	
1st grade eggs	354
2nd grade eggs	13

Summer Test.—Teams laying the greatest number of 1st grade eggs in the period December 1st to February 14th (inclusive). Teams to have laid 1,200 1st grade eggs in the period of the test. Cups donated by the Western Ice Company.

Section B—Team of 6 birds—Heavy breeds—Runnymede Poultry Farm—283 1st grade.

Teams from sections A and C did not qualify for these awards.

Section A—Highest single—Light breed.	
1st (Macfarlane Cup) Webb's Hatchery—	
1st grade eggs	256
2nd grade eggs	7
2nd (James Goss Trophy) H. P. Chalmer—	
1st grade eggs	249
2nd grade eggs	8
Section B—Highest single Heavy breed.	
1st (Bairds Co. Cup) N. T. Wilkinson —	
1st grade eggs	250
2nd grade eggs	12
2nd (Barrow Linton Trophy) Mrs. S. Dolman—	
1st grade eggs	248
2nd grade eggs	4
Section C—Highest single—Medium-heavy breed.	
1st (Enston Cup) Robinson Bros.—	
1st grade eggs	220
2nd grade eggs	0
2nd (Harrold & Murray Trophy) Robinson Bros.—	
1st grade eggs	212
2nd grade eggs	0

First bird to lay 200 first-grade eggs—

Light (J. & W. Bateman Trophy) H. P. Chalmer, Bird No. 129—2nd December, 1939. 262 days.

Heavy (T. Newby Trophy) F. Landquist & Sons, Bird No. 105—21st November, 1939. 251 days.

Medium-Heavy (R. Young Trophy) Robinson Bros., Bird No. 157—15th January, 1940. 304 days.

Special Prizes—

Robinson Trophy—Team laying lowest percentage of 2nd grade eggs (minimum total lay of 1,000 first-grade eggs)—

Mrs. M. H. Dadley (White Leghorns) 1,097 first-grade, 3 second grade.

A. S. Webb Trophy—Bird laying longest sequence of first-grade eggs—

Mrs. M. H. Dadley—Bird No. 87—69 eggs.

DETAILED RESULTS

SECTION "A" (LIGHT BREEDS)—TEAMS OF SIX BIRDS.

Name of Competitors and Birds Nos	1st.	2nd	1st	2nd	1st.	2nd.	1st	2nd.	1st	2nd	1st.	2nd.	Totals. 1st	Totals. 2nd.
T. Gent— 1—6	109	25	30	54	144	67	206	2	164	7	207	1	860	156
R. Knight— 7—12	192	25	85	9	214	13	105	72	29	167	162	21	787	307
13—18	82	145	194	7	146	6	175	1	126	97	150	1	873	256
Thorpe Poultry Farm— 19—24	112	4	82	22	159		150	2	142	4	127	13	772	45
G. E. Robinson— 25—30	120	5	73	91	159	3	164	28	118	7	111	22	745	156
A. R. Caporn— 31—36	133	32	223	14	176	2	112	5	180	9	149	42	973	104
L. Rushton— 37—42	85	66	120	77	43	122	105	45	102	40	190	11	645	361
Mrs. R. Lowe— 43—48	98	107	153	73	151	47	128	28	163	25	175	15	868	295
R. Lowe— 49—54	150	13	172		151	11	150	26	152	39	104	57	879	146
F. Harris— 55—60	192	9	143	7	213	3	142		120	72	1	6	811	97
D. F. Kashmir— 61—66	117	8	13	1	142	15	41	1	163	7	107	33	583	65
W. & E. Kerr— 67—72	147	19	184	2	150	1	95	1	71	..	86	13	733	36
Cranleigh Poultry Farm— 73—78	12	46	169	11	73	6	187		130	5	164	3	735	71
W. G. Hall— 79—84	205	4	147		118	14	187	38	206	10	104	99	967	165
E. Singleton— 85—90	195	5	179	1	168	5	190	2	127	34	182	6	1041	53
Webb's Hatchery— 91—96	115	45	256	7	150	25	210	25	176	21	168	35	1075	158
97—102	200	1	138	1	2	3	52	32	174	32	204	34	770	103
R. Harrison— 103—108	164	2	163	2	215		122	19	158	..	169	2	991	25
109—114	210	9	87	72	177	5	86	143	168	1	133	6	861	236
Mrs. E. E. Price— 115—120	229	1	152	.	162	4	172	2	209	1	140		1064	8
E. E. Price— 121—126	137	...	170	4	131	1	21	39	167	28	81		707	72
H. P. Chalmers— 127—132	127	7	62	19	249	8	210	6	99		182	17	929	57
Mrs. M. H. Dadley— 133—138	166		195	1	189		175	.	160	1	212	1	1097	3
M. H. Dadley— 139—144	166	14	159	1	105	...	107	125	70	114	174	20	781	274
Brown Leghorns. Runnymede Poultry Farm— 145—150	127	4	93	52	1	123	113	2	67	60	76	60	477	301

MONTHLY AVERAGES—*continued.*

Month.	No. of Birds and Breed.	Total No. of 1st Grade Eggs Laid.	Average.	Total No. of 2nd Grade Eggs Laid.	Average.	Average for all Grades.
January ...	134 W.L. ...	1,682	12·55	480	3·58	16·13
	141 Aus. ...	1,813	12·85	276	1·96	14·81
	34 R.I.R. ...	369	10·85	43	1·26	12·11
	6 B.L. ...	36	6·0	67	11·16	17·16
February (14 days)	134 W.L. ...	694	5·17	234	1·74	6·91
	141 Aus. ...	804	5·7	94	·6	5·13
	34 R.I.R. ...	180	5·29	25	·73	6·02
	6 B.L. ...	17	2·83	18	3·0	5·83

YEARLY AVERAGES.

	1st Grade.	2nd Grade.	Average All Grades.
White Leghorns .	144.71	23.01	167.72
Australorps	166.83	19.94	186.77
Rhode Island Reds ..	130.0	7.48	137.48
Brown Leghorns	79.5	50.16	129.66

AVERAGE FOR ALL BIRDS IN TEST.

	1st Grade.	2nd Grade.	Total.
All Birds	151.86	20.48	172.34

WINTER TEST RESULTS.

(March 16th to July 31st -138 days.)

Winners.	No. of Eggs.	Average.
Light Breeds—Mrs. M. H. Dadley, White Leghorns ..	480	80
Heavy Breeds—R. Harrison, Australorps .. .	471	78.5
Medium Heavy Breeds—Beverley Poultry Farm, Rhode Island Reds	354	59

LAYING AVERAGES FOR WINTER TEST.

(16th March to 31st July—138 days.)

	1st Grade.	2nd Grade.	All Grades.
White Leghorns	41.81	6.07	47.88
Australorps	52.15	7.97	60.12
Rhode Island Reds	43.08	1.55	44.63
Brown Leghorns	2.5	3.83	5.88

SUMMER TEST.

(1st December to 14th February—76 days.)

Winners.	1st Grade	2nd Grade.
Heavy Breeds—Australorps, Runnymede Poultry Farm ..	283	2

Sections A and C—White Leghorns and Rhode Island Reds: No Award as no team reached 1,200 eggs.

SUMMER TEST—ALL TEAMS.

(1st December to 14th February—76 days.)

	1st Grade.	2nd Grade.	All Grades.
White Leghorns	32.57	8.73	41.30
Australorps	32.76	4.95	37.71
Rhode Island Reds	18.83	23.66	42.49
Brown Leghorns	27.81	3.47	31.28

Comparison of ten leading pens during the last four years—

	1936–37. 1st.	1936–37. 2nd.	1937–38. 1st.	1937–38. 2nd.	1938–39. 1st.	1938–39. 2nd.	1939–40. 1st.	1939–40. 2nd.
10 pens White Leghorns ...	960·8	21·7	1,074·6	8·06	1,106·6	54·4	988·9	99·4
10 pens Australorps ...	1,128·6	12·11	1,268·6	7·06	1,181·4	99·9	1,128·1	95·8
6 pens Rhode Island Reds	798·2	220·0	901·2	149·1	902·8	123·0	758·3	43·6

COPPER BANDED BIRDS.

Copper band No.	Trial No.	Breed.	Owner.	No. 1st Grade Eggs.
65	4	White Leghorn	T. Gent	206
66	6	White Leghorn	T. Gent	207
67	9	White Leghorn	R. Knight	214
68	32	White Leghorn	A. R. Caporn .. .	223
69	57	White Leghorn	F. Harris	213
70	79	White Leghorn	W. G. Hall	205
71	83	White Leghorn	W. G. Hall	206
72	92	White Leghorn	W. R. Webb ..	256
73	94	White Leghorn	W. R. Webb	210
74	97	White Leghorn	W. R. Webb	200
75	102	White Leghorn	W. R. Webb	204
76	105	White Leghorn	R. Harrison	215
77	109	White Leghorn	R. Harrison . ..	210
78	115	White Leghorn	Mrs. E. E. Price ..	229
79	119	White Leghorn	Mrs. E. E. Price ..	209
80	129	White Leghorn	H. P. Chalmer ..	249
81	130	White Leghorn	H. P. Chalmer ..	210
82	138	White Leghorn	Mrs. M. H. Dadley	212
159	151	Australorp	E. O. Harrison ..	200
160	153	Australorp	E. O. Harrison ..	233
161	154	Australorp	E. O. Harrison ..	219
162	155	Australorp	E. O. Harrison ..	217
163	157	Australorp	T. Sudell & Son ..	224
164	158	Australorp	T. Sudell & Son ..	206
165	162	Australorp	T. Sudell & Son .	201
166	1	Australorp	N. T. Wilkinson ..	203
167	2	Australorp	N. T. Wilkinson ..	250
168	3	Australorp	N. T. Wilkinson ..	229
169	4	Australorp	N. T. Wilkinson ..	208
170	6	Australorp	N. T. Wilkinson ..	205
171	9	Australorp	A. Wilkinson ..	230
172	11	Australorp	A. Wilkinson ..	203
173	14	Australorp	H. Seal	204
174	31	Australorp	L. Rushton	220
175	43	Australorp	W. & E. Kerr ..	241
176	44	Australorp	W. & E. Kerr ..	228
177	53	Australorp	S. Dolman	207
178	58	Australorp	W. G. Hall	225
179	61	Australorp	R. Harrison	220
180	63	Australorp	R. Harrison	243
181	64	Australorp	R. Harrison	203
182	66	Australorp	R. Harrison	212
183	69	Australorp	R. Knight	233
184	70	Australorp	R. Knight . ..	237
185	71	Australorp	R. Knight	233
186	75	Australorp	R. Knight	224
187	79	Australorp	E. O. Harrison ..	231
188	80	Australorp	E. O. Harrison ..	210
189	81	Australorp	E. O. Harrison ..	216
190	84	Australorp	E. O. Harrison ..	200
191	85	Australorp	Mrs. M. H. Dadley ..	221
192	86	Australorp	Mrs. M. H. Dadley ..	233
193	90	Australorp	Mrs. M. H. Dadley ..	213

Copper banded Birds—*continued.*

Copper band No.	Trial No.	Breed.	Owner.	No. 1st Grade Eggs.
194	91	Australorp	M. H. Dadley	213
195	95	Australorp	M. H. Dadley	215
196	98	Australorp	Mrs. S. Dolman ..	248
197	102	Australorp	Mrs. S. Dolman ..	228
198	103	Australorp	F. Landquist & Sons ..	235
199	105	Australorp	F. Landquist & Sons ..	247
200	109	Australorp	Mrs. E. E. Price ..	241
201	114	Australorp	Mrs. E. E. Price ..	230
202	115	Australorp	E. E. Price	222
203	119	Australorp	E. E. Price	222
204	130	Australorp	M. Wall	204
205	132	Australorp	M. Wall	200
206	154	Rhode Island Reds	R. Wilson & R. Penton	200
207	157	Rhode Island Reds	Robinson Bros. ..	220
208	161	Rhode Island Reds	Robinson Bros. ..	212

In the above trial 68 birds qualified for copper rings, or 20.54 per cent.

The Champion team was a pen of Australorps entered by N. T. Wilkinson of South Belmont.

The total of 1,256 first grade eggs was 19 eggs lower than the winner of 1938-39.

Mrs. M. H. Dadley of Spearwood won in the White Leghorn section. The team laid 1,097 first grade eggs, this being 164 less than 1938-39.

In the Rhode Island Red section, Robinson Bros. of Belmont won with a team which laid 990 first grade eggs, this being 26 in advance of 1938-39.

Bird No. 87 owned by Mrs. M. H. Dadley laid a sequence of 69 eggs.

FEEDING.

Feed Consumed.	1936–37.	1937–38.	1938–39.	1939–40.
Wheat	190½ bushels	165½ bushels	224¾ bushels	231½ bushels
Pollard	186 „	191 „	227½ „	226½ „
Bran	207 „	178 „	224 „	282 „
Wheatmeal ...	6,798 lbs.	6,469 lbs.	8,438 lbs.	9,493 lbs.
Bonemeal ...	747 „	990 „	932 „	1,072 „
Meatmeal ...	1,700 „	1,962 „	2,870 „	3,312 „
	5·14 oz. (per fowl per day)	5·13 oz. (per fowl per day)	5·16 oz. (per fowl per day)	5·16 oz. (per fowl per day)

The cost of feeding for the 48 weeks in the 1939-40 trial was £133 14s. 8d. or equal to 8s. 1d. per bird, while the net average return for eggs was 16s. 3¼d. The average profit was 8s. 2¼d. per bird.

	1936–37.	1937–38.	1938–39.	1939–40.
Cost of Feed	9/9¼	10/3	6/10	8/1
Average Gross Profit ...	8/10	9/2¼	11/8	8/2¼

Note.—**Feeding costs are based on the retail prices of all goods as charged by metropolitan produce merchants, whilst the returns for eggs are those received in open sales less 5 per cent. selling commission, and a deduction of an account sales fee of 6d. per sale day (a sum equal to £2 12s. per annum).**

Associations for the Improvement of Dairy Herds in Western Australia.

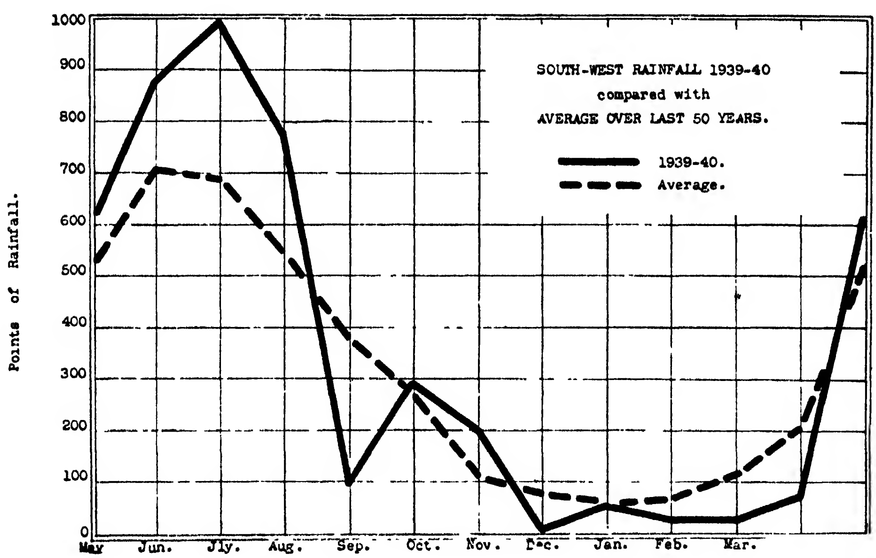
REPORT FOR YEAR ENDING 30th APRIL, 1940.

G. K. BARON-HAY, Superintendent of Dairying.

G. SLATER, Recording Officer.

The season 1939-40 was an unfavourable one for the growth of pasture. Rains commenced late in autumn and continued above the normal until the end of August, followed by very few useful registrations during September, thus causing annual pasture plants to form seed prematurely, which prevented their normal growth during October and November. This unfavourable spring was accentuated by lighter falls than normal during succeeding summer months. This is clearly shown in the following figures for rainfall during 1939-40, compared with the average precipitation and in the accompanying graph:--

Year.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.	Total Points.
1939–40	51	25	28	69	617	884	903	771	96	287	201	13	4,035
Average	51	65	109	201	534	701	681	547	379	269	107	73	3,717



The unfavourable season was reflected particularly in the yields of hay and in the conservation of silage, both of which were below the normal.

As would be expected, the production of butterfat during the summer months throughout the State was less than in previous years, although the flush production was approximately equal to that of the previous year.

Another factor which has militated against higher production during the past year has been the unsettled effect on farmers of the outbreak of war, and also the difficulty of obtaining labour through the enlistment of experienced helpers, all of which have tended to reduce average yields.

Table 1 shows the average production of cows under test in the Herd Recording scheme during 1939-40, and includes all cows which were under test for three months or more.

TABLE 1.

AVERAGE PRODUCTION PER COW.

No. of Herds.	No. of Cows.	Milk. lbs.	Test. %	Butterfat. lbs.
465	11,479	4,620	4·51	208·29

The average production of butterfat shows a reduction of approximately 10 lbs. per cow, which may be ascribed almost entirely to the conditions outlined above.

For comparison, the average production per cow since 1933-34—during which year grade herd recording was commenced—is shown in Table 2 below.

TABLE 2.

AVERAGE PRODUCTION PER COW, 1934–1940.

Year.	No. of Cows.	Milk. gals.	Test. %	Butterfat. lbs.
1933–34	4,038	415	4·35	180·6
1934–35	4,088	456	4·56	207·8
1935–36*	4,590	459	4·51	207·3
1936–37†	9,115	434	4·53	196·7
1937–38*	10,033	486	4·59	223·1
1938–39‡	12,368	487	4·48	218·7
1939–40	11,479	462	4·51	208·3

* 1 new Unit. † 9 new Units. ‡ 6 new Units.

No new associations were commenced during the year, and, not only amongst members of associations, but amongst dairy farmers generally, there is a tendency to under-value the importance of maintaining production.

In view of the very special need which has been expressed in Great Britain for the supply of dairy produce, and the special arrangements which are being made for its transit overseas, it is thought that the maintenance of the production of dairy foods can be regarded legitimately as a major effort towards winning the war.

Furthermore, such effort aims at not only increasing yield, but in improving efficiency in production, and is a wise precaution as a safeguard for severe competition during the post war period, not only from other dairying countries, but also from the possibility of the use of substitutes. Therefore, rather than relax efforts at increased and economical production, there is every reason why all means which would ensure this should be adopted, one of the chief of which is grade herd recording.

Plenty of sunlight, concrete floors and marshalling yard, white wash at least once a year.

Production per Cow in each Unit.

The average production per cow in each unit is shown below in Table 3.

TABLE 3.

PRODUCTION PER COW IN EACH UNIT.

Unit.		No. of Herds.	No. of Cows.	Percentage of Heifers.*	Milk.	Test.	Butterfat. 1939–40.	Butterfat. 1938–39.
					lbs.	%	lbs.	lbs.
A.	Donnybrook ...	22	474	32	4,249	4·79	203·30	230·10
B.	Serpentine ...	16	368	36	5,397	4·30	232·16	236·90
C.	Cookernup ...	21	672	39	5,322	4·46	237·70	252·05
D.	Harvey	22	479	34	5,023	4·69	235·52	244·42
E.	Brunswick ...	21	597	35	5,371	4·68	251·88	284·37
F.	Dardanup ...	21	554	35	4,471	4 48	199·51	216·94
G.	Capel	20	841	40	4,799	4·13	198·02	222·18
H.	Balingup ...	24	658	34	4,726	4·66	220·37	262·10
I.	Forest Grove ...	23	498	27	4,578	4·60	210·96	240·58
J.	Pemberton ...	19	354	21	4,740	4·79	227·41	244·76
K.	Rosa Brook ...	23	546	30	4,413	4·71	208·07	221·57
L.	Vasse	16	367	25	3,844	4·28	159·60	171·91
M.	Manjimup ...	24	645	18	4,271	4·42	187·47	209·19
O.	Benger	17	472	38	4,923	4·30	214·00	233·67
P.	Pinjarra	19	489	47	4,385	4·69	205·67	218·20
Q.	Greenbushes ...	18	402	31	4,207	4·62	194·63	222·19
S.	Albany	24	491	20	4,968	4·43	220·16	196·83
T.	Bridgetown ...	19	533	30	4,075	4·47	182·34	184·76
U.	Metricup ...	15	215	9	4,107	4·73	193·90	250·36
V.	Ruabon	20	530	29	4,414	4·33	191·13	188·97
W.	Northcliffe ...	22	496	27	3,862	4·43	171·29	180·89
X.	Cowaramup ...	22	467	30	4,471	4·58	204·94	195·45
Y.	Narrogin ...	17	331	56	4,684	4·45	208·20	164·04

* Including cows 2 and 3 years old.

During the year 14 units, embracing 6,896 cows, produced over 200 lbs. butterfat per cow, which yield is considered the lower limit for profitable production.

The Brunswick Unit again filled first place with an average production of 252 lbs. butterfat which, however, is 32 lbs. below the production in the previous year. This is an indication of the difficult conditions which dairy farmers experienced owing to the unfavourable season.

One feature which all these units, except Donnybrook, have in common is that, when herd recording was commenced, the average production of cows was considerably below the 200 lb. mark, which is the minimum regarded as profitable; productions ranging from 160 lbs. butterfat per cow in the Cookernup Unit to 188 lbs. per cow in the Dardanup Unit.

A good-looking cow, but no guarantee of production or persistency.

In the case of the Donnybrook Unit, dairy farming is combined with general mixed farming, including fruit-growing, and the system there has been to calve cows as early as possible in the autumn in order that they may be dried off in January so as not to interfere with the work of picking and packing fruit. Furthermore, the herds in this district were above the average as far as breeding is concerned and mainly of the Jersey breed.

It will be noticed that this unit always has shown productions considerably above the economic minimum, but that the productions have fluctuated up and down from year to year between 220 and 275 lbs. butterfat per cow, and it will be noticed further that in other units the maxima which have been reached are within these same limits.

It is found in practice extremely difficult for whole units embracing 500 to 700 cows to maintain an average production of 250 lbs. butterfat consistently, by reason of the extreme difficulty in obtaining pure-bred bulls with a sufficiently high butterfat backing to increase yields above this figure. This difficulty is shown by reason of the fact that during 1939-40 the average production of all pure-bred cows submitted for official test was approximately 306 lbs. butterfat per cow.

In examining the production records of associations given in Table 3, it is well to remember that all cows which were tested for three months or over during the year are included in these records, and that the actual production of each cow for a full lactation period may be considerably greater than the herd average.

This is shown clearly in Table 4, which has omitted the productions of all cows which did not complete a nine months' testing period, but includes those cows which dried off naturally or for other causes during the year.

TABLE 4.

PERCENTAGE OF COWS COMPLETING LACTATION.

Unit.	Cows.	Butter Fat.	Unit Average Butter Fat.
	%	lbs.	lbs.
A. Donnybrook	83	211·30	203·30
B. Serpentine	81	240·10	232·16
C. Cookernup	70	274·17	237·70
D. Harvey	85	249·99	235·52
E. Brunswick	72	250·74	251·88
F. Dardanup	57	212·57	199·51
G. Capel	81	203·50	198·02
H. Balingup	88	226·27	220·37
I. Forest Grove	71	234·78	210·96
J. Pemberton	81	236·52	227·41
K. Rosa Brook	55	235·85	208·07
L. Vasse	68	166·00	159·60
M. Manjimup	86	196·44	187·47
O. Benger	96	214·56	214·00
P. Pinjarra	79	224·31	205·76
Q. Greenbushes	93	198·29	194·63
S. Albany	87	239·83	220·16
T. Bridgetown	99	182·40	182·34
U. Metricup	45	246·01	193·90
V. Ruabon	43	219·02	191·13
W. Northcliffe	61	195·82	171·29
X. Cowaramup	70	233·94	204·94
Y. Narrogin	83	220·94	208·20

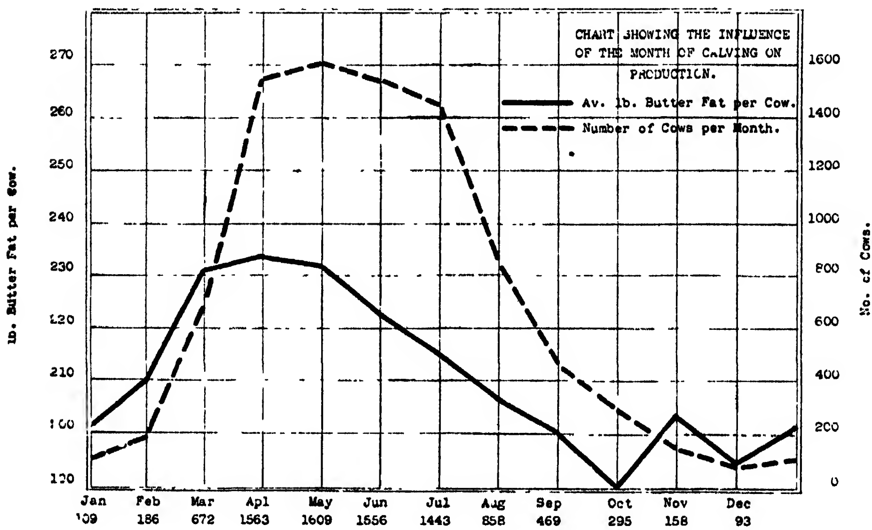
It will be noticed that, where the percentage of cows that calved early in the season is high, it is in those units that the 273-day records approach more closely the unit average. It is obvious that, in order to obtain a nine months' testing period by 30th April in each year, cows should not be submitted for test after the end of July, and during the present year the lesson of the advantage of early calving has been particularly demonstrated in view of the dry summer period.

It is true that higher productions could be obtained by lengthening the lactation period by hand-feeding, but with large herds this may be unprofitable compared with the grazing of cows on natural pasture for a longer period which could be obtained by early calving.

The advantage of the commencement of lactation periods early in the autumn is clearly shown in the attached graph, where it will be seen that cows which calved during the period from March to May produced, on the average, approximately 230 lbs. butterfat, and that cows calving subsequent to May showed a decreasing production to a minimum of under 190 lbs. butterfat in October, and that the average production of cows did not exceed 200 lbs. until lactation periods commenced after December.

In certain units it is necessary to keep as even a production as possible throughout the whole year for a supply of milk to the metropolitan area or for the manufacture of cheese or condensed milk, and it is specially desirable that such a spreading of production throughout the year should be attempted at the present juncture.

From this graph, which is similar to that of previous years, it will be seen that continuity of supply is most profitably obtained by endeavouring to arrange that cows do not calve during the period from October to the middle of January but that the production of milk during this period should be kept up by cows calving not later than September and again early in the new year. At these times of calving, the indications are that cows will produce larger quantities than if they calve during the months of October to December.



Herds grouped according to Production.

In Table 5 the herds in the scheme are grouped according to the average production of butterfat, and the last year's results are compared with the previous year 1938-39 and the first year of testing in 1933-34.

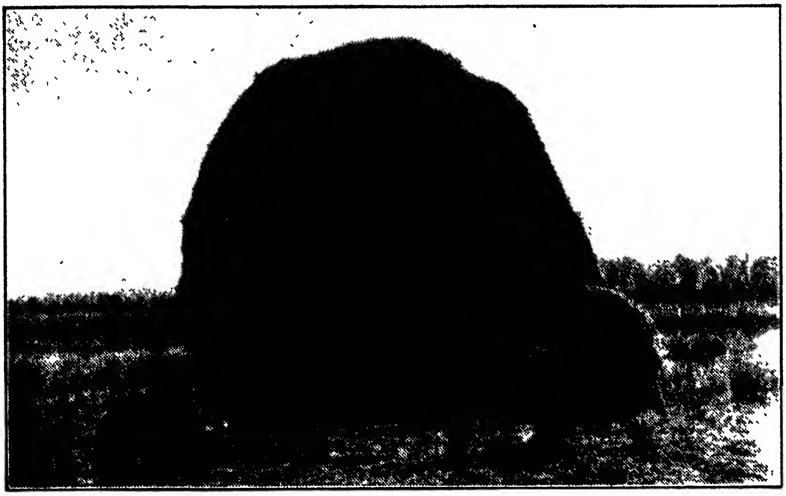
It will be noted that, whereas in the first year of testing (1933-34) nearly three-quarters of the herds under test failed to produce 200 lbs. butterfat per cow, by 1938-39 these low producing herds had been reduced to approximately 30% but that, during the next season, 1939-40, the percentage of herds grouped in the "Under 200 lbs. of Butterfat" class had increased by 11%.

TABLE 5.

HERDS GROUPED ACCORDING TO PRODUCTION.

	Butter Fat per Head. (lb.)							
Year.	Over 400.	350–400.	300–350.	250–300.	200–250.	150–200.	100–150.	Under 100.
	%	%	%	%	%	%	%	%
1933–34	...	...	1·31	3·93	20·30	53·55	18·30	2·61
1938–39	...	·40	7·40	23·30	37·50	25·20	5·80	·40
1939–40	...	...	3·23	18·48	34·62	32·89	9·69	1·08

In view of the fact that new units were not commenced during the year, and herd recorders advised that the quality of cows was considered quite equal to those tested in the previous year, the fall in production could be ascribed fairly to seasonal conditions, particularly as these conditions affected the quantity of fodder conserved.



Fodder reserves are of particular value in a dry season. An excess of requirements should be built up in good years

It is regretted that no concerted efforts were made by dairy farmers during the past summer to take practical steps to overcome the shortage of conserved fodder which had become apparent by hay-cutting time.

In a number of instances farmers took the precaution of sowing increased areas of summer crops—in some instances—of sowing crops where none at all had been planted for a number of years. In these instances, the acute shortage of hay was not felt so severely and also enabled the hay to be reserved for the autumn months when it would be of most use.

It is not improbable that the present season, which has opened comparatively unfavourably, may be a repetition of the year 1939-40, and it is hoped that all dairy farmers will take the precaution of planting as large an area as possible with a summer fodder such as maize, sorghum, millett, or cow peas, with the view of eking out the hay crops should these be below normal. A review of rainfall records in the past indicate that, if such crops are planted early, it is extremely unlikely that useful returns will not be obtained.

Cows grouped according to Age and Production.

After making due allowance for production according to age, it is found that there is approximately the same percentage of mature cows and junior cows which failed to attain 200 lbs. butterfat during their lactation period.

During the initial years of the scheme it was noted that the production of heifers, after making due allowance for age, was considerably in excess of the

average production of mature cows, which indicated that the breeding policy generally of dairy farmers—namely, the use of a pure bred bull consistently of the one breed—was bearing fruit. As would be expected, however, as the average production of herds increased, there has been an increasing difficulty among farmers in obtaining sires with a sufficiently high "butterfat backing" to improve and—in some instances—to maintain the higher herd averages.

It will be noticed in Table 6 that the percentage of heifers under test is unusually high, approximately 30%, which indicates that farmers have taken the opportunity—whilst meat prices have been high—to cull their herds more severely than normally not only for low production but also for age.

Silage will not deteriorate. Large quantities could have been conserved in year of plenty —1938.

TABLE 6.

COWS GROUPED ACCORDING TO AGE AND PRODUCTION.

(Cows tested less than 90 days excluded.)

Groups according to Butter Fat Production (lb.).

Age Class.	Over 600.	500–600.	400–500.	300–400.	200–300.	150–200.	100–150.	Less than 100.	Total Cows.
	%	%	%	%	%	%	%	%	
Mature	...	1	1·2	12·7	46·4	23·0	12·2	4·4	7,813
Junior*	...	·1	·1	4·2	32·6	30·1	23·7	9·2	3.666

*Including cows 2 and 3 years old.

In view of the necessity of increasing production as quickly as possible, it would appear that herds are in a sound position to enable this to be done, as severe culling should not be necessary for several years, particularly as the normal percentage of heifers need not exceed approximately 17% or one heifer for every six

milking cows to maintain the herd at full strength. It is hoped that every effort will be made to increase the numerical strength of herds by more intense farming or by bringing new herds under production.

TABLE 7.

HIGHEST PRODUCING COW IN EACH UNIT.

Owner.	Unit.	Name of Cow.	Tattoo.	Breed.	Test.	Butter Fat.
					%	lb.
F. Byrd ...	Harvey ...	Chrissie ...	DT 518	Friesian x Jersey	4·61	574·97
R. L. Maidment	Capel ...	Gentle ...	GW 8	Shorthorn x Jersey	5·48	571·28
P. Fitzpatrick ...	Cookernup ...	Darby ...	C9C 47	do.	4·44	561·94
D. Della ...	Pemberton ...	Tiger ...	JN 5	Guernsey x Jersey	5·20	545·17
Narrogin School of Agriculture	Narrogin ...	Cloud ...	YD 6	Ayrshire ...	4·46	540·50
G. S. Blaikie ...	Cowaramup ...	Clue ...	KL 31	Shorthorn ...	3·95	530·53
A. Tomerini ...	Balingup ...	Violet ...	HJ 48	Jersey ...	6·12	520·89
Ellis Bros. ...	Brunswick ...	Jenny ...	EB 10	Jersey x ...	5·74	508·96
F. G. William's ...	Pinjarra ...	Grannie ...	PM 24	Friesian ...	3·74	508·61
L. Westcott ...	Serpentine ...	Queenie ...	BG 19	Shorthorn x Jersey	6·10	490·18
O. Foan ...	Donnybrook...	Poppy ...	AL 20	Jersey ...	5·11	479·30
W. Darnell ...	Rosa Brook ...	Tiny ...	IU 13	Jersey x Guernsey	6·03	472·44
F. A. Fenning ...	Forest Grove	Sally ...	IN 6	Guernsey ...	5·45	438·83
J. Gilmour ...	Dardanup ...	Seven ...	FE 7	Jersey ...	4·58	429·85
G. Henderson ...	Bridgetown ...	Mintie ...	TH 9	do. ...	5·16	429·41
P. W. Buckeridge	Albany ...	Darkie ...	SΩ 10	Shorthorn x	4·34	423·25
W. Donaldson ...	Metricup ...	Spot ...	UV 2	Shorthorn ...	4·63	419·10
W. K. Barnes ...	Benger ...	Squib ...	OG 17	do. ...	4·20	415·15
H. G. Letchford	Greenbushes...	Gipsy ...	QX 4	Jersey ...	5·40	394·53
A. J. S. Angel ...	Manjimup ...	Daffodil ...	MZ 7	Guernsey ...	4·13	392·81
F. Oliver ...	Northcliffe ...	Creamy ...	W ⟼ 4	do. ...	4·10	376·05
J. Singleton ...	Ruabon ...	Sybil ...	VY 10	Jersey x Shorthorn	4·99	367·38
R. J. Seymour...	Vasse ...	Fat Brownie	L ⍝ 6	Jersey x	4·52	342·93

In Table 7 the highest producing cow in each unit is shown, the cow "Chrissie" owned by Mr. F. Byrd, Harvey, being the highest producing cow in the scheme with an average production of 574.97 lbs. butterfat.

It will be seen that, although the season has been an unfavourable one, the production of the highest cow in each unit is consistently good, and in no less than nine herds such cows produced over 500 lbs. butterfat during the year.

In Table 8 those herds containing less than 20 cows with an average production of over 280 lbs. butterfat per cow are listed.

It is interesting to note that these herds occur in districts throughout the whole of the South-West and even on the Great Southern and are an indication that, where ample provision has been made for fodder conservation or, in some instances, for the provision of irrigated pasture which takes the place of conserved fodder it is possible to maintain extremely high average productions during one of the severest years experienced in the State.

TABLE 8.

LEADING HERDS OF LESS THAN 20 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lb.
D. Della	Pemberton	14	Guernsey ...	319·85
W. J. Burt	Cowaramup	17	Jersey ...	317·93
R. L. Maidment	Capel	16	Shorthorn ...	316·90
A. Bracknell	Albany	17	do. ...	310·68
W. Donaldson	Metricup	8	...	303·57
J. Fuller	Albany	15	Jersey ...	302·11
E. Booth	Narrogin	18	Shorthorn ...	301·37
O. Foan	Donnybrook	18	Jersey ...	300·06
H. G. Letchford	Greenbushes	16	do. ...	297·86
L. A. House	Pinjarra	18	do. ...	292·67
S. J. Alexander	Cookernup	11	Shorthorn ...	289·30
J. Hill	Cookernup	17	Friesian ...	288·76
Bell Bros.	Brunswick	13	do. ...	287·87
T. Twaddle	Cookernup	19	Jersey ...	287·77
R. Thompson	Pemberton	17	Guernsey ...	286·95
School of Agriculture ...	Narrogin	17	Shorthorn ...	286·90
Mrs. A. G. Eckersley ...	Harvey	18	Jersey ...	286·36
G. W. Marston	Brunswick	18	Shorthorn ...	285·15
J. J. Littlefair	Pemberton	13	Jersey ...	284·26
G. E. Johnston	Rosa Brook	15	...	282·45
P. O'Farrell	Forest Grove	19	do. ...	280·29
C. I. Kasten	Brunswick	16	do. ..	280·03

The following Table 9 gives a list of those herds of from 20 to 40 cows producing more than 290 lbs. butterfat per cow. Two years ago no herds in this group produced over 300 lbs. butterfat per cow, and the owners of the herds in Table 9 are to be congratulated on the average production of these large herds in an unfavourable season.

TABLE 9.

LEADING HERDS OF 20–40 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter Fat Average.
				lb.
J. Hartley	Brunswick	35	Jersey ...	345·65
C. P. House	Capel	33	Shorthorn ...	335·31
Mrs. L. R. Barnsby ...	Pemberton	20	Guernsey ...	319·17
P. Fitzpatrick	Cookernup	39	Shorthorn ...	304·53
Ellis Bros.	Brunswick	25	do. ...	302·46
L. M. Temple	Harvey	25	Jersey ...	300·09
A. Miller	Cowaramup	24	do. ...	296·18
R. Hutchinson	Brunswick	27	do. ...	295·81
J. H. Iseppi	Cookernup	31	Jersey x Friesian	293·20
W. B. Blaikie	Cowaramup	25	Jersey ...	292·98

Two interesting points are brought out in the list of high producing herds:—

Firstly: That throughout the Herd Recording Scheme those herds which consistently achieve the highest production are those which are composed either of pure-bred cows or of cows which have been bred consistently to the same breed of carefully selected sires, so that the cows are in appearance and may be regarded genetically as of reasonably pure blood.

This is a policy which has been proved successful in other countries where dairying is of importance; and it is believed that the nearer the herd approaches any one of the pure dairy breeds the higher will be the average production, and that with a crossbred herd, although high production may be obtained for one or two years, there is extreme difficulty and certainly an element of luck in maintaining this high yield.

Secondly: That in any list of herds of less than 20 cows there is ample representation from districts south of Bridgetown and Busselton, that is, in the comparatively recently developed areas. However, in the herds of larger numbers, exceeding 20, the representation of such districts is small and almost non-existent where herds exceed 40 in number.

It is apparent that the majority of dairy farmers in the extreme South-West are not increasing the size of their herds as rapidly as might be expected, particularly in view of the good prices that have been ruling for butterfat for several years.

It is thought sound that the present should be regarded as a favourable time to use every effort to bring new ground into production—or by other means increase the size of herds—not only because there is a demand for dairy produce, but because this is one of the best means whereby dairy farmers may prepare themselves for any post-war fall in prices.

In Table 10 appears a list of herds of over 40 cows with an average production of more than 230 lbs. butterfat per cow.

TABLE 10.

LEADING HERDS OF OVER 40 COWS.

Owner.	Unit.	No. of Cows.	Breed.	Butter-fat Average.
				lb.
A. Tomerini	Balingup	41	Jersey ...	319·42
W. K. Barnes	Benger	44	Shorthorn ...	289·78
J. Salerian	Cookernup	79	Jersey ...	286·15
Mrs. D. B. Rose	Brunswick	53	do. ...	275·27
G. W. Payne & Sons ...	Capel	53	Ayrshire ...	269·47
D. Scott	Balingup	48	Jersey ...	262·33
K. Prowse	Capel	45	do. ...	245·10
S. H. Fry	Benger	43	Shorthorn ...	243·56
W. Atkins	Dardanup	48	Jersey ...	239·15
Mrs. C. M. Corker	Harvey	44	do. ...	239·14

The average productions of the herds given in Tables 8, 9, and 10 should be pondered over carefully by owners of pure-bred herds which have been submitted for test during the past season.

Preparations should be made to sow large areas with maize this spring.

Sorghum is a prolific summer crop, and if sown thickly will provide dry roughage for the winter months.

It will be apparent that there are very few pure-bred herds in the State which can supply bulls in any numbers with ancestry having sufficiently high butterfat production records to increase the average productions of some of the herds being tested in the Grade Herd Recording Scheme.

Although the number of pure-bred cows under test may be a small percentage of cows in the State, stud breeders hold one of the "key" positions for the successful development of the dairying industry and for the planning of any scheme aimed at a reduction in the costs of production. This is realised by the committees of management of the three principal dairy breeds, who during the last few years have taken steps to endeavour to prevent the registration of stock which are considered untrue to type; but, in order to achieve practical results, just as great an effort should be made to ensure that the average productions of these breeds should be raised also in order to fill the needs of such herds as are listed in the three Tables Nos. 8, 9, and 10.

"Proved" Bulls.

Following the practice which was commenced in 1936-37, a further list of "proved" pure-bred bulls having six or more daughters that have been tested and have produced over 200 lbs. butterfat per cow has been compiled and is given below in Table 11.

TABLE 11.

ADDITIONAL LIST OF BULLS HAVING SIX OR MORE DAUGHTERS AVERAGING OVER 200 LBS. BUTTERFAT.

Name of Bull	No. of Daughters Averaged.	Average Butter-fat Production.	Unit.	Owner or Late Owner.	Age of Bull.
Australian Illawarra Shorthorn—					
Kaleula Gold Digger	13	290	Capel ...	C. P. House ...	9
Maxicar Paul ...	11	310	Brunswick ...	J. Hartley ...	7
Starlight of Wongong	29	256	Albany ...	F. Pease ...	...
Telyarup Bill ...	8	221	Manjimup ...	W. Hamilton ...	Dead
Widgee Waa Record	23	223	Brunswick ...	C. L. Clarke & Co.	10
Wooroloo Bruce ...	10	210	Balingup ...	R. T. Meade ...	6
Ayrshire—					
Creamy Prince ...	6	291	Dardanup ...	T. P. Harris ...	4
Denbeigh Maxine's Manxman	23	257	Capel ...	G. W. Payne ...	9
Tipperary Moonlight	6	299	Dardanup ...	T. P. Harris ...	...

TABLE 11—*continued.*

ADDITIONAL LIST OF BULLS HAVING SIX OR MORE DAUGHTERS AVERAGING OVER 200 LBS. BUTTER FAT—*continued.*

Name of Bull.	No. of Daughters Averaged.	Average Butter-fat Production.	Unit.	Owner or Late Owner.	Age of Bull.
Friesian—					
Cadalelup Plus Patch	10	242	Serpentine ...	G. Bett	7
Chittering Korndyke Veeman	11	299	Harvey ...	F. Byrd	Dead
Dunmore Bountilad	7	255	Serpentine ...	W. Taylor ...	7
Guernsey—					
Drakesbrook Baron...	10	296	Balingup ...	M. Brennan ...	8
Koojan Cherub ...	8	229	Manjimup ...	G. Braid ...	Dead
Lansdowne Radiant Chief	7	268	Narrogin ...	T. H. James ...	Dead
Muresk Minos ...	6	256	Manjimup ...	M. Kilrain ...	Dead
Newry Lad	6	260	Narrogin ...	S. M. Butcher ...	11
Rosewood Melody Chief	6	219	Pemberton ...	M. Humphry ...	13
Wollongbar Comet ...	10	238	Manjimup ...	H. Brown ...	Dead
Wollongbar Justice...	10	264	do. ...	A. J. S. Angel ...	Dead
Jersey—					
Brookvale Reward ...	12	202	Balingup ...	G. C. White ...	6
Burekup Laddie ...	18	203	Greenbushes...	E. G. Pollard ...	Dead
Colmyn Cyclone ...	15	329	Cookernup ...	J. Salerian ...	...
Colmyn Victor ...	12	286	Cowaramup ...	M. J. Walter ...	4
Devonia Bing Boy ...	7	232	Pinjarra ...	L. A. House ...	Dead
Eastbrook Tribute ...	6	287	Pemberton ...	D. Della ...	Dead
Fascinator of Juadine	12	291	Donnybrook...	G. Layman ...	Dead
Garden Hill Paymaster	6	268	Ruabon ...	H. Semmens ...	Dead
Glen Royal	7	289	Donnybrook...	O. Foan	Dead
Grantham Air Prince	9	296	do. ...	A. C. Frost ...	8
Grass Vale King Twylish	13	254	Brunswick ...	A. F. Clifton & Co.	6
Grass Vale Montrose Twylish	11	269	do. ...	R. A. Clifton ...	Dead
Greenmount Snowstorm	10	236	Pinjarra ...	J. Davidson ...	5
Jock of Australind ...	13	211	Bridgetown ...	J. Sparks ...	Dead
Juadine Robin ...	9	252	Narrogin ...	E. Loynel ...	7
Larry of Juadine ...	9	262	Bridgetown ...	J. Sparks ...	Dead
Leo of Applegrove ...	7	204	Northcliffe ...	C. H. Collins ...	9
Mereworth Belvedere Starbright	8	212	Balingup ...	Mrs. H. K. Ellis	6
Mokine Samson ...	6	223	Manjimup ...	J. W. Marqueson	Dead
Mokine Hercules ...	6	241	Bridgetown ...	J. Collins ...	11
Nooka King Ragtime	8	303	Narrogin ...	E. Loynel ...	10
Silver Knight of Trelawney	6	280	Ruabon ...	C. W. Casselton	Dead
Tap of Leithvale ...	10	203	Manjimup ...	Young & Emery	9
Tavistock Silver Prince	10	253	Rosa Brook ...	J. P. Smith ...	11
Thurgoona Seaplane	9	266	do. ...	H. Pickering ...	10

During the previous three years the names of 145 bulls and the average production of their daughters, together with the names of the owners of these bulls where such are known, were published, and the present list contains the names of a further 45 "proved" sires.

Average Production of all Units.

Particulars of the production of the herds in all units which were under test during 1939-40 are appended hereunder.

Donnybrook "A."	No. of Cows.	Butter Fat Average.
		lbs.
O. Foan "L"	18	300·06
A. C. Frost "C" ...	17	272·16
W. J. Sears "A" ...	30	263·50
Herd U	30	244·49
" G*	17	243·17
" F*	20	240·43
" K	13	235·40
" E	20	230·92
" RA	12	224·21
" C	12	217·92
" —A	21	183·56
" D	43	182·42
" RX	30	181·57
" RJ*	11	179·91
" —B	35	174·99
" E	35	172·89
" C*	21	171·53
" RY	10	170·89
" RR	13	167·24
" X	32	167·17
" A*	20	162·80
" RP	14	119·94

Serpentine "B."	No. of Cows.	Butter Fat Average.
		lbs.
L. Westcott "G" ...	25	289·27
G. Scott "U"	14	264·19
R. H. Briggs "V" ..	12	260·63
Herd R	28	249·72
" D*	22	245·60
" Y .. .	12	244·97
" L	9	244·26
" T	37	233·85
" X	17	227·64
" M	11	227·48
" S	29	227·31
" A	66	225·08
" O	37	211·15
" H	26	206·54
" N	14	188·48
" C	9	172·30

* Letter reversed.

Cookernup "C."	No. of Cows.	Butter Fat Average.
		lbs.
P. Fitzpatrick "9C" ...	39	304·53
J. H. Iseppi "F" ‡ ...	31	293·30
S. J. Alexander "R" ...	11	289·30
Herd P	17	288·76
" J‡	20	287·77
" CS	79	286·15
" Y	15	275·47
" 2C	10	273·69
" K‡	26	268·95
" E‡	22	264·37
" T	20	263·24
" L	31	236·05
" F	63	230·32
" D	22	215·70
" Z	21	214·48
" Y‡	45	211·80
" Q‡	36	203·93
" 7C	61	202·14
" V	52	194·10
" J	30	184·82
" 6C	20	171·43

Harvey "D."	No. of Cows.	Butter Fat Average.
		lbs.
L. M. Temple "C" ...	25	300·09
Mrs. A. G. Eckersley "E"	18	286·36
E. J. Manning "NH" ...	25	284·06
Herd E*	23	255·59
" NM	20	252·01
" F*	15	246·59
" A†	25	244·46
" T	30	241·29
" B	23	241·11
" CC	44	239·14
" CE	19	237·86
" AD	29	235·20
" NB	14	228·49
" AC	32	220·51
" L*	18	215·48
" AG	14	208·34
" AN	14	204·61
" G*	19	202·51
" CA	13	198·69
" NT	18	193·86
" G	35	193·78
" J*§	6	176·79

* Letter reversed. † Tested 8 months only. ‡ Letter inverted. § Tested 5 months only.

Average Production of all Units—continued.

Brunswick "E."	No. of Cows.	Butter Fat Average.
		lbs.
J. Hartley "M" * ...	35	345·65
Ellis Bros. "B" ...	25	302·46
R. Hutchinson "R" * ...	27	295·81
Herd P*	13	287·87
,, A*	25	287·03
,, E*	18	285·15
,, Q	31	283·64
,, C*	38	283·19
,, D	16	280·03
,, B*	53	275·27
,, A	35	257·87
,, T*	18	257·07
,, V*	19	252·26
,, H	31	252·20
,, U	39	232·46
,, Q*	20	220·69
,, K*	31	213·75
,, E	39	201·67
,, L*	23	197·70
,, U*	20	172·14
,, S*	41	141·25

* Letter reversed

Dardanup "F."	No. of Cows.	Butter Fat Average.
		lbs.
J. Gilmour "E" ...	24	290·29
D. Strachan "C" ...	23	272·72
W. Anderson "A† R†"	10	260·63
Herd A† E†	26	254·36
,, I	16	250·94
,, 5	20	243·59
,, D	48	239·15
,, M	20	229·72
,, A† N	23	226·69
,, A† T	14	218·49
,, A	19	207·32
,, A† W	31	190·40
,, K	43	183·87
,, A† K†	15	173·62
,, A† V	44	166·11
,, A† P	31	161·80
,, A† M†	43	156·99
,, A† M	26	156·07
,, A† U	22	153·60
,, A† D†	37	151·96
,, A† C†	19	123·77

† Letter inverted.

Capel "G."	No. of Cows.	Butter Fat Average.
		lbs.
C. P. House "D" ...	33	335·31
R. L. Maidment "W"	16	316·90
G. W. Payne & Son "X"	53	269·47
Herd A*	45	245·10
,, I	52	213·47
,, M	39	213·30
,, A	64	211·84
,, B‡	30	205·76
,, C	30	204·31
,, N	31	199·26
,, V	54	184·06
,, Z	57	181·16
,, E	45	180·98
,, J	35	175·30
,, Q	37	173·41
,, B	53	157·93
,, C‡	37	155·28
,, R	42	146·73
,, D‡	69	145·32
,, O	19	144·11

Balingup "H."	No. of Cows.	Butter Fat Average.
		lbs.
A. Tomerini "J" ...	41	319·42
A. M. Brazier "A" * ...	30	279·79
Mrs. H. K. Ellis "N" ...	25	270·46
Herd S	30	268·63
,, R	21	266·85
,, K	48	262·33
,, Y	17	256·82
,, F†	39	255·54
,, H9	20	245·52
,, Q	18	212·29
,, D†	15	211·98
,, P	22	211·38
,, K†	48	208·72
,, C	48	203·56
,, G†	47	202·49
,, E	22	193·02
,, H3	10	185·98
,, B†	32	170·20
,, H4	27	168·23
,, L§	24	158·79
,, D	18	157·22
,, J†	22	145·24
,, H5	31	145·22
,, F	10	142·11

* Letter inverted. † Letter reversed. ‡ Letter inverted. § Tested 5 months only.

Average Production of all Units—continued.

Forest Grove "I."	No. of Cows.	Butter Fat Average. lbs.	Pemberton "J."	No. of Cows.	Butter Fat Average. lbs.
H. Eddy "U" ...	30	281·21	D. Della "N"	14	319·85
T. A. Fenning "N" ...	33	280·92	Mrs. L. R. Barnsby "B"	20	319·17
P. O'Farrell "L"* ...	19	280·29	R. Thompson "AF" ...	17	286·95
Herd F‡	27	280·16	Herd G	13	284·26
" V	12	256·31	" U	19	275·61
" Z	23	230·01	" AB	16	255·77
" T‡	20	228·95	" V	15	250·52
" T	17	228·41	" L	15	235·18
" J‡	26	223·02	" T	7	233·83
" G‡	11	206·73	" H	11	233·28
" WB	17	205·76	" F	24	232·85
" C	17	205·36	" A	17	232·15
" BB	20	203·64	" R	22	231·17
" W‡	21	190·04	" Y	19	224·95
" D*	16	185·76	" P	12	208·98
" Q‡	27	179·73	" O	12	207·96
" E	16	179·02	" Z	17	203·59
" D	39	173·95	" AE	10	202·83
" K*	22	173·22	" D	23	189·33
" E*	28	171·22	" AD§	21	149·03
" V‡	19	159·26	" X...	12	128·06
" A‡	23	144·09	" AC‡	18	113·55
" AB	15	142·93			

* Letter reversed. ‡ Letter inverted. § Tested 9 months only. ‡ Tested 7 months only.

Rosa Brook "K."	No. of Cows.	Butter Fat Average. lbs.	Vasse "L."	No. of Cows.	Butter Fat Average.
N. Ranson "A" ...	32	284·34	D. H. Bell "Z" ...	9	259·40
G. E. Johnston "T"*...	15	282·45	R. J. Seymour "P"†...	24	228·02
T. C. Minchin "Y"* ...	20	266·25	M. and I. Drakes "A"†	12	217·85
Herd Q	19	265·76	Herd C	29	203·98
" E	19	245·97	" H	29	199·77
" F*	13	242·45	" N†	34	179·26
" U	29	234·77	" X	16	175·64
" P	14	231·00	" U†	21	174·10
" J*	18	218·96	" M†	23	167·06
" B	27	214·21	" G†	12	143·68
" R*	37	212·27	" S†	29	139·51
" E*	31	210·94	" R†	24	126·54
" G*	24	195·60	" Y	48	117·97
" Z	20	191·18	" O	45	105·51
" C	16	190·43	" J†‖	2	86·22
" H...	44	187·46	" F†‖	10	65·07
" B*	31	184·93			
" W	17	184·46			
" A*	16	178·66			
" F	27	173·46			
" D	24	166·79			
" G	23	160·23			
" D*	30	133·32			

* Letter inverted. † Letter "lazy." ‖ Tested 3 months only.

Average Production of all Units—continued.

Manjimup "M."	No. of Cows.	Butter Fat Average. lbs.	Benger "O."	No. of Cows.	Butter Fat Average. lbs.
C. I. Doust "A" ...	27	268·33	W. K. Barnes "G" ...	44	289·78
A. R. Jones "V" ...	7	257·38	T. B. Stanley "M" ...	18	258·19
A. J. S. Angel "Z" ...	29	242·41	S. H. Fry "A" † ...	43	243·56
Herd H	14	235·73	Herd L	38	242 06
" Q	15	229·40	" AD	17	241·12
" I	14	227·63	" Y	17	221 30
" C	25	223·51	" AF	18	217·48
" B*	27	219·01	" D	21	214·21
" D*	29	216·94	" J	37	213·07
" N	17	212·87	" AE	15	194·27
" R*	16	202·95	" AJ	24	188·09
" D	19	201 66	" AB	41	185·72
" B	28	198·92	" X	29	182·76
" M	38	196·47	" AC	16	177·21
" P	62	191·35	" S	41	174·57
" E	20	186·15	" T	35	174·11
" A†	41	186 15	" C	18	130·73
" W	20	175·14			
" J	19	170·92			
" E*	27	162·70			
" T	32	156·38			
" R	30	154·07			
" K*	14	141·08			
" O	38	116·71			
" Y	38	112·51			

* Letter reversed. † Letter inverted.

Pinjarra "P."	No. of Cows.	Butter Fat Average. lbs.	Greenbushes "Q."	No. of Cows.	Butter Fat Average. lbs.
L. A. House "L" ...	18	292 67	H. G. Letchford "X"	16	297·86
J. Davidson "A" † ...	31	267·92	T. Giblett "P" † ...	12	269·06
F. G. Williams "M" ...	26	260·67	W. Taylor "U" ...	15	265·45
Herd B*	12	259·02	Herd C	34	226·11
" J	23	252·21	" Q	18	211·34
" B	36	233·72	" J†	21	208·84
" A	45	230·42	" G	28	204·49
" N	27	228·19	" E	14	203·72
" U	30	226·02	" Z	59	193·77
" V	22	209·29	" P	33	185·60
" F	20	205·79	" Y†	14	181·22
" D*	30	204·04	" I	29	178·93
" AB	18	201·36	" V†	18	171·29
" G	38	200·04	" B	20	166·25
" E*	26	177·97	" V	34	160·39
" C	28	176·92	" T†	12	159·16
" K	26	134·99	" J	16	134·23
" T	55	108·90	" L	9	75·61
" F*	9	95·70			

* Letter reversed. † Letter inverted.

Average Production of all Units—continued.

Albany "S."	No. of Cows.	Butter Fat Average.
		lbs.
A. Bracknell "A" ‡ ...	17	310·68
J. Fuller "E" * ...	15	302·11
J. Woods "Z" * ...	11	277·96
Herd Q‡	14	277·10
,, F	10	262·73
,, M‡	26	260·89
,, L	35	255·71
,, G*	14	252·76
,, B	22	240·36
,, F*	18	223·25
,, U‡	16	222·13
,, J	13	220·71
,, V‡	34	218·21
,, E	19	212·36
,, Y	16	205·01
,, I	27	203·91
,, B*	21	202·17
,, K*	19	201·87
,, P*	27	194·70
,, C*	26	191·51
,, D*	25	185·16
,, R	14	183·79
,, X	24	182·38
,, T	28	110·97

Bridgetown "T."	No. of Cows.	Butter Fat Average.
		lbs.
G. Henderson "H" ...	23	268·27
W. Watson "C" ...	16	230·75
G. Dixon "K" ...	22	216·81
Herd I	42	210·98
,, J	23	208·82
,, A	46	208·41
,, Y	29	192·24
,, S	16	190·90
,, Q	39	182·97
,, D	44	178·97
,, G	29	177·27
,, E	31	169·44
,, X	29	169·23
,, N	32	153·06
,, B*	17	148·50
,, M	30	144·66
,, Z	19	136·32
,, U	28	130·31
,, F	18	129·51

‡ Letter inverted. * Letter reversed.

Metricup "U."	No. of Cows.	Butter Fat Average.
		lbs.
W. Donaldson "V" ...	8	303·57
R. Hart "L"	10	250·41
W. F. Webster "N" ...	28	245·65
Herd Q	20	233·34
,, B	24	224·15
,, T	11	219·77
,, M	15	198·44
,, Z	18	181·57
,, F	15	179·88
,, X	19	178·82
,, I	6	125·98
,, Y	14	120·72
,, A	7	112·64
,, G	11	103·69
,, O	9	77·54

Ruabon "V."	No. of Cows.	Butter Fat Average.
		lbs.
W. Casselton "F" * ...	15	261·69
J. Singleton "Y" ...	14	239·53
H. Semmens "X" ...	42	238·23
Herd K	30	228·52
,, H	30	223·42
,, D	9	219·67
,, N	30	216·15
,, P*	27	211·71
,, F	32	196·21
,, O	18	178·25
,, R	22	176·28
,, B	44	172·21
,, L	20	171·98
,, S	36	171·06
,, E	23	169·05
,, T	33	164·23
,, V	45	163·36
,, Z	17	162·38
,, A	30	154·78
,, B*	13	128·84

* Letter reversed.

Average Production of all Units—continued.

Northcliffe "W."		No. of Cows.	Butter Fat Average.	Cowaramup "X."		No. of Cows.	Butter Fat Average.
			lbs.				lbs.
G. R. Pratt "B"	...	21	242·53	W. J. Burt "H"	...	17	317·93
F. Oliver "I" *	...	19	216·40	A. Miller "KM"	...	24	296·18
J. Daubney "D" *	...	23	216·02	W. B. Blaikie "A"	...	25	292·98
Herd M ...	...	24	211·75	Herd C	...	17	253·01
" J	...	28	202·11	" KI ...	...	21	251·10
" H ...	...	16	201·18	" KL ...	...	17	237·35
" C	...	26	191·14	" N	...	14	233·66
" F	...	28	184·94	" I	...	24	223·35
" N* ...	...	26	181·57	" K ...	...	20	212·54
" Z	...	23	179·04	" R	...	20	203·69
" U	...	36	171·34	" E	...	13	199·23
" P	...	21	169·43	" X ...	...	19	198·32
" L	...	12	166·24	" O	...	21	191·75
" O	...	23	165·70	" D	...	24	190·24
" G	...	34	165·40	" T	...	21	188·12
" T	...	16	136·70	" F	...	29	187·46
" R	...	18	131·21	" G	...	17	186·11
" K ...	...	22	123·63	" KY ...	...	22	179·05
" S	...	21	121·65	" Y	...	24	166·75
" V	...	15	121·50	" P	...	16	160·18
" X† ...	...	27	117·17	" L	...	35	157·05
" E‡ ...	...	17	109·69	" KJ ...	...	27	150·50

* Letter "lazy." † Tested 7 months only. ‡ Tested 9 months only.

Narrogin "Y."		No. of Cows.	Butter Fat Average.
			lbs.
E. Booth "E"	...	18	301·37
Narrogin School of Agriculture "D"		17	286·90
H. Trefort "F"	...	12	259·59
Herd H ...	...	13	258·94
" I	...	11	256·66
" B	...	64	229·29
" N	...	24	206·66
" A	...	45	198·50
" C	...	10	192·85
" G	...	19	183·64
" O	...	12	179·15
" K ...	...	14	171·98
" L	...	13	154·44
" J	...	16	150·95
" Q	...	10	150·50
" P	...	14	147·34
" M ...	...	19	146·07

Sires of the Farmer's Flock.

By Hugh McCallum, Sheep and Wool Adviser.

The foundation of the flock is laid by the selection of a good even line of ewes—preferably a registered breeder's "cast for-age" line, which sheep have been carefully selected over a period of years and have been the mothers of the breeding flock—and the future success is influenced by the adoption of correct methods of husbandry, but the keystone around which the flock will be built up is represented by the rams—the sires who will leave their mark on the sheep of future generations. It is with these "grand old men" of the sheep world that this article will deal.

No matter what the ultimate object may be, the production of wool or export lambs, its achievement depends greatly on the rams provided. Just "male sheep" are a matter of easy obtaining, but "sires" need to be carefully considered, inspected and selected. Whatever the breed, only pure-bred rams should be used.

The flock owner must mentally picture the type of sheep he desires to breed up to and thereafter must cull, mate and select to attain that type, correcting defects and improving quality each season. There is no short cut in breeding that will give satisfactory results and the ideal can only be obtained by systematic breeding gradually fixing the desired characteristics. Too frequently the sheep owner attempts to quickly improve his flock by the purchase of rams, often very high grade animals, regardless of their suitability for mating with his ewes, and then is most disappointed with the progeny. The ram is too important a factor and has too great an influence to be introduced into the flock without first being carefully considered as to type and subjected to a rigid and thorough examination. The outward appearance may be attractive, but the wool is often a deceiving factor and close inspection will reveal many defects in constitution and conformation not discernible at first glance. If possible, an inspection soon after shearing and again when the animals are in full wool, is a wise plan.

It must be ever remembered that the first essential in building up a flock is constitution, and given this, other attributes to a good ram are masculinity; bold appearance; well-shaped and well-carried head; good squarely set jaw with solid even teeth; bright eyes; strong frame with straight back; well-sprung ribs; plenty of width across the shoulders; deep girth, giving heart and lungs plenty of room; wide chest; well-set on, sturdy legs, with strong healthy hooves; a good carriage with a free walk. A big-boned animal is preferable as thin-boned and cow-hocked or knock-kneed rams are usually poor walkers and should be avoided.

A flock man who has not been associated with sheep long enough to enable him to visualise his breeding objective should seek the advice of an experienced sheepman regarding the best lines to work on to effect permanent improvement and he is well-advised to purchase his rams annually from a reliable registered breeder.

The value of the registered breeders in the industry is now always fully realised and appreciated by the newer flock man. It enables owners to purchase sires and at the same time indirectly gives them valuable assistance in assuring that such sires have behind them the characteristics desired and the power to impart them, thus giving the owner the benefit of the knowledge gained in the life-long study of sheep by well-experienced men. Again, there is an assurance of sound constitution in such rams and this quality of fundamental importance is largely the product of hereditary influence which the stud breeder has

developed by years of careful culling, mating and selection. Another aspect of the advantage the registered breeder affords is that the register of stud flocks, which is issued annually by the central organisation of stud breeders throughout the Commonwealth, enables the new flock owner to select and purchase from a breeder whose stock are of a blood strain akin to that to which his foundation ewes belong.

When once satisfactory rams have been obtained it is wiser for the flock owner to purchase his annual draft of rams from the same breeder, than to change from blood to blood. This enables him on every occasion to select sires that are particularly outstanding in any characteristic where the ewes show weakness and to be sure that the mating will be satisfactory.

From mating to mating the rams must be cared for. The average mortality in rams is generally higher than it should be and the percentage of efficient rams at mating season could be greatly increased by the regular and careful inspection of sires. Immediately after they are removed from the ewes, they should be yarded and examined individually to see that no damage has been sustained while at work and any small injuries should be dressed. At all seasons of the year rams will fight, and broken places, about the head in particular, are very apt to get fly-blown if not dressed. Lack of attention will result in the undermining of the animal's health and probably mean a poor lambing percentage. Throughout the year the animals must be paddocked where there is good feed and ample water supply, and some months prior to mating special care must be taken to assure that the animals are in the best of condition and full of vigour, though, of course, not over-fat and lazy.

Good foundation ewes, correct husbandry measures and the selection of high class suitable rams, cannot but build up successfully the flock of any sheepman.

The Official Australian Pure Bred Dairy Cattle Production Recording Scheme.

G. K. BARON-HAY (Superintendent of Dairying) and G. SLATER (Recording Officer).

In preparing the following tables showing the results of Pure Breeds Herd Testing for the year ended 30th June, 1940, it was anticipated that the effect of the unfavourable season during 1939 would be reflected in production, but this is not the case, as the 382 cows under review yielded an average of 6,629 lb. of milk at 4.61 per cent. test, equal to 305.88 lb. of butter fat without age allowances, the highest average since the year 1934-35. Twenty-five cows which were tested less than 150 days and were withdrawn owing to sickness or sale, have not been included in any of the averages, although their productions are recorded in Table 3.

The number of cows passing the various standards remains fairly constant from year to year and, as will be seen in Table 1, the Guernsey breed, though numerically weak, has maintained its position with the highest percentage of passes. The Jerseys, which suffered a marked decline a few years ago, have improved considerably, while the Shorthorns have dropped below the average, mainly as the result of poor yields in the three-year-old classes.

Similar low productions in these classes were evident last year, and it is thought that the tendency to bring heifers of this breed into profit too early may affect the yield during the second and third lactations. In fact, the records of some cows indicate that the strain of early calving is not completely overcome until maturity,

and this may account to some extent for the comparatively poor productions recorded by Messrs. D. Bevan & Son's "Blacklands Ettie 9th" before making her State record yield of 776.91 lb. butter fat this year.

TABLE 1.
COWS PASSING STANDARD.

Age Class.	A.I.S.		Guernsey.		Jersey.		All Breeds.	
	No. of Cows Tested.	No. Passing Standard.	No. of Cows Tested.	No. Passing Standard.	No. of Cows Tested.	No. Passing Standard.	No. of Cows Tested.	No. Passing Standard.
Mature	51	20	22	16	39	18	112	54
Senior 4 years ...	3	1	4	2	10	3	17	6
Junior 4 " ...	17	12	9	7	12	8	38	27
Senior 3 " ...	20	6	2	2	15	10	37	18
Junior 3 " ...	16	6	10	8	11	9	37	23
Senior 2 " ...	30	15	4	4	17	14	51	33
Junior 2 " ...	40	25	20	16	30	24	90	65
Totals ...	177	85	71	55	134	86	382	226
Per cent. Passing Standard ...	48·0		77·5		64·2		59·2	

For the third year in succession the Champion Herd Sire was the well-known imported Guernsey bull "Homestead Ace" (1631) owned by Mr. A. W. Padbury of Koojan, his leading six daughters averaging 515.94 lb. butterfat, or with age allowances, 555.36 lb. Among the daughters was "Koojan Ace's Jewel II." which, during the year, yielded an Australian record for a junior 4-year-old Guernsey cow of 683.45 lb. butter fat in 273 days.

TABLE 2.
AVERAGE BUTTER FAT PRODUCTION IN EACH CLASS.

Age Class.	A.I.S.		Guernsey.		Jersey.		All Breeds.	
	No. of Cows.	Average Butter Fat.	No. of Cows.	Average Butter Fat.	No. of Cows.	Average Butter Fat.	No. of Cows.	Average Butter Fat.
		lb.		lb.		lb.		lb.
Mature	51	348·67	22	408·24	39	324·02	112	351·79
Senior 4 years ...	3	313·67	4	328·83	10	317·45	17	319·46
Junior 4 " ...	17	363·90	9	398·00	12	340·60	38	364·62
Senior 3 " ...	20	271·84	2	331 08	15	332·04	37	299·45
Junior 3 " ...	16	253·13	10	284 68	11	328·39	37	284·03
Senior 2 " ...	30	254·91	4	349·94	17	282·91	51	271·70
Junior 2 " ...	40	243·66	20	263·10	30	256·81	90	252 36

Table 2 discloses how seasonal conditions, mammitis and other complaints, and the difficulty of successfully mating cows at the desired time, all tend to lower production in the older classes as many of the animals now figuring as mature cows, and only just passing the standard, have exceeded the standard by a considerable margin in previous lactations. The mature Jersey cows are well below the average, but as the productions of this breed in the younger sections have shown a marked improvement over the last few years, it can be expected that the standard for mature cows will gradually rise.

TABLE III.

COWS WHICH COMPLETED TEST DURING THE TWELVE MONTHS ENDED 30TH JUNE, 1940.

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Milk for Last Day.	Milk for Period.	Average Test	Average Butter Fat.	Owner	Sire.
COWS UNDER 2½ YEARS—STANDARD 230 LB. BUTTER FAT.											
						lb.	lb.	%	lb.		
Wattle Creek Vera	A.I.S.		10-10-36	17-12-38	273	25	8,415	4·36	367·49	E. T. Thatcher	Wooroloo Duchess' Guardian (3621)
Koojan Bo-Peep 2nd	Guernsey	7246	2-4-37	15-1-39	273	23	6,609	5 39	355·90	A. W. Padbury	Koojan Ace's Aristocrat (2730)
Brookfields Beauty	do.	6831	30-9-36	16-12-38	273	25	6,743	5 22	351 75	P. G. Hampshire	Koojan Ace's Majestic (2735)
Grantham Dreaming Fairy	Jersey	61951	6-4-37	22-6-39	273	12 5	6,053	5·30	321 00	J. A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Greenmount Milk Maid 2nd	do.	.	20-9-37	16-8-39	273	13	6,114	5·23	319·53	A. J. B. Strempel	Greenmount Bonetienne's Tornado (11662)
Wooroloo Sunbeam	A.I.S.	23273	24-10-36	29-12-38	273	24	7,437	4·24	315·13	Wooroloo Sanatorium Farm	Wooroloo Triumph 3rd
Crantock Golden Bell	Jersey		13-8-37	25-9-39	273	8	5,454	5·73	312·56	Mrs. G. H. Burnside	Congelin Eminent's Golden (13623)
Glanavon Lulu	A.I.S.		25-10-36	10-2-39	273	29	7,497	4 15	311·09	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Congelin Tangerine 2nd	Jersey		30-8-37	22-6-39	273	13	6,144	5·01	308·23	B. P. Hack	Rosecliffe Marchalong (15094)
Brookfields Morden Lady 2nd	Guernsey	6838	19-9-37	9-9-39	273	14	6,012	5·11	306·64	P. G. Hampshire	Koojan Ace's Majestic (2735)
Wooroloo Joy 3rd	A.I.S.	23252	16-8-37	22-8-39	273	21	7,488	4·06	303·86	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Brookfields Honour	Guernsey	6836	8-9-37	9-9-39	273	13	5,139	5·87	301·59	P. G. Hampshire	Koojan Ace's Majestic (2735)
Brookfields Duchess	do.	6835	3-6-37	5-5-39	273	7·5	5,502	5·48	301·22	W. Darnell	Brookfields Majesty (3254)
Crantock Silk Socks	Jersey		6-6-37	9-3-39	273	21	6,183	4 84	299 46	Mrs. G. H. Burnside	Congelin Eminent's Golden (13623)
Colmyn Golden Dawn	do.	65987	8-10-37	3-9-39	273	8	5,799	5 07	293·96	C. H. Ironmonger	Clarendon Eyre Golden Oxford (13606)
Crantock Starbright Napoleonette 2nd	do.	.	5-7-37	5-4-39	273	20	5,535	5·22	288 90	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Rutherwood Rosebud	Guernsey	7827	15-7-37	18-8-39	273	14	5,967	4·81	287·07	Claremont Hospital for Insane	Denmark Robin Hood (3322)
Claremont Mabel 10th	A.I.S.		4-4-37	18-8-39	273	20	6,945	4·10	288·36	Misses Rutherford	Wooroloo Triumph 4th (3627)
Congelin Iolanthe 2nd	Jersey		7-6-37	9-4-39	273	14 5	4,724	6·07	286·82	B. P. Hack	Clarendon Eyre Eminent's Geishar 4th (13597)
Wooroloo Pearl 5th	A.I.S.	23624	1-10-36	17-2-39	273	18	6,234	4·54	282·83	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Denmark Orange Pekoe	Guernsey	5444	11-6-36	6-10-39	273	19	6,717	4·61	282·35	Denmark Research Station	Denmark Damon (2519)
Radyr Park Princess 3rd	Jersey		17-6-37	17-8-39	273	7	4,836	5·83	281·86	L. Temple	Greenmount Graceful Lad (7292)
Congelin Iolanthe 3rd	do.		10-6-37	28-3-39	273	21	6,183	4·54	280·83	B. P. Hack	Clarendon Eyre Eminent's Geishar 4th (13597)
Glanavon Doris 5th	A.I.S.	..	5-12-36	14-1-39	273	26	6,798	4·09	278·09	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Glanavon Elaine 2nd	do.	.	14-2-37	19-4-39	273	18	5,907	4·66	275·05	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Crantock Eminent's Sunshinette	Jersey		1-1-37	7-3-39	273	20	5,910	4 64	274·52	Mrs. G. H. Burnside	Congelin Eminent's Golden (13623)
Glanavon Ettie	A.I.S.	.	25-2-37	10-5-39	273	20	6,630	4·12	273·29	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Koojan Ace's Wavelet 2nd	Guernsey	7245	2-3-37	14-1-39	273	15	4,703	5·81	273·08	A. W. Padbury	Homestead Ace (imp.) (1631)
Denmark Angeline	do.	6956	4-7-37	24-9-39	273	18	5,199	5·22	271·46	Denmark Research Station	Koojan Golden Prosper (2283)

Yanget Gwen 2nd	A.I.S.	....	12-11-36	26-3-39	273	23	8,079	3·36	271·45	A. E. Grant	Leylands Defiance (2380)
Radyr Park Dorothy 7th	Jersey	...	26-6-37	16-7-39	273	10·5	4,682	5·78	270·96	L. Temple	Radyr Park Estrellita's Duplex (15050)
Yanget Flash 2nd	A.I.S.	23300	14-8-36	13-1-39	273	29	7,407	3·66	270·59	A. E. Grant	Sunrise of Parkview (1875) (I.M.S.)
Yanget Champagne's Lovely	do.	23294	2-5-36	6-10-38	273	11	6,318	4·26	268·99	A. E. Grant	Sunrise of Parkview (1875) (I.M.S.)
Coogely Jonquil	Guernsey	6945	1-11-37	26-4-39	273	13	4,532	6·03	268·40	Denmark Research Station	Coogely Judy's Goldmine (2621)
Claremont Mabel 8th ..	A.I.S.	. .	13-9-36	14-2-39	273	26	6,993	3·83	268·29	Claremont Hospital for Insane	Claremont Herdsman (968)
Colmyn Golden Joy ...	Jersey	65988	3-9-37	4-6-39	273	10·5	5,042	5·31	267·99	C. H. Ironmonger	Clarendon Eyre Golden Oxford (13606)
Wooroloo Rita	A.I.S.	23268	27-2-37	30-5-39	273	16	6,483	4 10	267·42	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Rosy Hill Pearl 10th	Jersey		1-6-37	19-8-39	273	16	4,863	5·48	266·61	M. T. Padbury ...	Glen Iris Star (9492)
Yanget Miss Tottie 2nd . .	A.I.S.	23307	10-9-36	26-12-38	273	20	6,000	4·42	265·31	A. E. Grant	Sunrise of Parkview (1875) (I.M.S.)
Crantock Golden Cream 3rd	Jersey	....	30-5-37	27-3-39	273	17	5,286	4·92	259 91	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Glanavon Addie 4th ...	A.I.S.	.	14-5-37	5-8-39	273	17	6,156	4·16	256 42	W. G. Burges	Glanavon Nimrod (437)
Wooroloo Favourite	do.	23242	19-6-37	2-4-39	273	19	6,237	4·11	256·40	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Koojan Ace's Delight ..	Guernsey	7249	18-11-36	1-1-39	273	17·5	5,018	5·09	254 64	J. R. Giles	Koojan Ace's Aristocrat (2730)
Denmark Du Barry ..	do.	6964	19-7-37	10-9-39	273	15	5,250	4·85	254·63	Denmark Research Station	Koojan Golden Prosper (2283)
Radyr Park Estrellita 2nd ..	Jersey	68753	26-8-36	13-10-38	273	12	4,431	5·66	250·91	L. Temple . . .	Radyr Park Lady's Starlight (13128)
Glanavon Dulcie 2nd .	A.I.S.		18-4-37	28-7-39	273	16	6,048	4·80	250·49	W. G. Burges	Parkview Commodore (306)
Crantock Napoleon's Lily ...	Jersey	66067	21-9-36	22-2-39	273	19 5	6,059	4·11	249·91	Mrs. G. H. Burnside .	Crantock Blonde's Napoleon (8207)
Glanavon Royal Venus ...	A.I.S.	.	5-10-36	26-3-39	273	13	5,529	4·52	249·81	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Brookfields Loyalty ...	Guernsey	6837	12-5-37	3-3-39	273	16	4,563	5·47	249·76	P. G. Hampshire ..	Koojan Ace's Majestic (2735)
Wooroloo Jeanette 3rd .	A.I.S.	.	2-8-37	4-10-39	273	16	5,718	4·35	248·96	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Garden Hill Linda	Jersey		23-4-37	23-9-39	273	13	4,224	5·88	248·35	W. Padbury	Clarendon Eyre Golden Oxford (13606)
Colmyn Goldflake .	do.	65982	20-8-37	2-8-39	273	9·5	5,804	4·25	246·62	C. H. Ironmonger . .	Clarendon Eyre Golden Oxford (13606)
Glanavon Melba	A.I.S.	..	21-12-36	9-3-39	273	18	6,864	3·59	246·02	D. Bevan & Sons ..	Parkview Commodore (306)
Crantock Eminent Cream ...	Jersey	. .	2-3-37	4-5-39	273	11	4,233	5·79	245·11	Mrs. G. H. Burnside .	Congelin Eminent's Golden (13623)
Colmyn Butter Queen .	do.	65981	14-1-37	25-6-39	273	9·5	4,349	5·63	245·04	C. H. Ironmonger ..	Colmyn Butter King (12568)
Colmyn Lola	do	65989	24-6-37	4-6-39	273	8·5	5,081	4·81	244·62	C. H. Ironmonger ...	Clarendon Eyre Golden Oxford (13606)
Wooroloo Beryl	A.I.S.	23231	12-2-37	16-5-39	273	16	5,433	4·45	241·91	Wooroloo Sanatorium Farm	Wooroloo Duke 6th (3611)
Brookfields Blonde ..	Guernsey	6834	24-8-37	10-9-39	273	8	4,164	5·81	241·85	P. G. Hampshire	Koojan Ace's Majestic (2735)
Glanavon Florrie .	A.I.S.		24-2-37	11-5-39	273	12	5,496	4·43	241·03	D. Bevan & Sons	Glanavon Nimrod (437)
Westby Dahlia ...	do.	.	17-9-37	26-8-39	273	13	6,549	3·64	238·58	Burkitt & Brown	Telyarup Duke (956)
Denmark Briar Rose	Guernsey	6959	15-8-37	20-9-39	273	14	4,902	4·78	234·22	Denmark Research Station	Denmark Illustrious (3320)
Glanavon Elsie 2nd .	A.I.S.	. .	29-1-37	15-1-39	273	20	5,970	3·90	233·13	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Denmark Bonnie Mary . .	Guernsey	6958	30-9-37	21-9-39	273	15	4,680	4·97	232·49	Denmark Research Station	Denmark Illustrious (3320)
Colmyn Gold Buttercup	Jersey	65986	2-9-37	4-9-39	273	10	5,325	4·35	231·83	C. H. Ironmonger	Clarendon Eyre Golden Oxford (13606)
Grantham Sweet Dreams 2nd	do.	61956	3-2-37	3-2-39	273	20·5	5,042	4·58	230·92	J. A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Glanavon Daphne 3rd ...	A.I.S.	...	13-2-37	29-4-39	273	17	5,661	4·00	226·82	D. Bevan & Sons	Parkview Commodore (306)
Wooroloo Poppy 3rd	do.	23266	9-5-37	4-4-39	273	13	5,019	4·52	226·28	Wooroloo Sanatorium Farm	Wooroloo Duke 6th (3622)

HERD TESTING—*continued.*

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Milk for Last Day.	Milk for Period.	Average Test.	Average Butter Fat.	Owner.	Sire.
COWS UNDER 2½ YEARS—*continued.*											
						lb.	lb.	%	lb.		
Claremont Rachel 11th ...	A.I.S.		2-5-37	17-8-39	273	16	5,658	3·98	225·20	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
Claremont Primrose 5th	do.		29-3-37	12-6-39	273	15	5,745	3·91	224·48	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
Garden Hill Lucky Ginger 2nd	Jersey		3-6-37	18-8-39	273	10	3,427	6·52	223·66	W. Padbury	Rosy Hill Perfection (14173)
Tipperary Dove 9th ..	A.I.S.	..	2-10-37	16-9-39	273	14	4,947	4·45	222·29	W. G. Burges	Blacklands Monarch's Commander (1877)
Wendowie Dainty	Guernsey	8080	5-9-37	2-9-39	273	9	4,467	4·94	220·60	S. F. Russell	Muresk Golden Chief (2925)
Wattle Creek Pride	A.I.S.		15-11-36	9-5-39	240	17	5,850	3·71	217·05	E. T. Thatcher ...	Yanget Autumn Sun (3630)
Yanget Pretty Maid 2nd	do.		28-10-37	7-10-39	273	13·5	4,616	4·69	216·50	W. G. Burges	Sunrise of Parkview (1875) (I.M.S.)
Claremont Maggie 9th	do.		28-11-36	9-1-39	273	16	5,433	3·95	214·29	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
Radyr Park Dorothy 8th	Jersey		24-8-37	29-6-39	273	9	4,002	5·35	214·16	L. Temple	Radyr Park Estrellita's Duplex (15050)
Wooroloo Rose 5th	A.I.S.	23270	9-11-36	14-10-38	273	8	4,254	5·01	213·29	Wooroloo Sanatorium Farm	Triumph of Pine Creek (2515)
Claremont Clara 9th	do.		19-7-36	1-11-38	273	18	5,409	3·93	212·46	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
The Wold Starbright Oxford	Jersey		31-5-37	6-7-37	210	11	3,915	5·17	202·62	L. C. Field	Clarendon Eyre Oxford Pioneer (11484)
Denmark Morning Glory	Guernsey	6967	21-6-37	24-9-39	273	10·5	4,067	4·88	198·40	Denmark Research Station	Denmark Damon (2519)
Coogely Heiress	do.	6944	15-5-37	7-10-39	240	11	4,140	4·70	194·28	P. G. Hampshire	Coogely Judy's Goldmine (2621)
The Wold Fairy Grey	Jersey		1-7-37	28-7-39	210	4·5	3,555	5·43	193·11	L. C. Field	Gratham Fairy King (13765)
Brookfields Queen 5th	Guernsey	6842	15-4-38	20-9-39	273	8	3,534	5·14	181·74	W. Darnell	Brookfields Baron (3936)
Travalgan Lady Elon 3rd	Jersey		15-3-38	24-4-39	273	9	2,892	6·24	180·45	Robinson Bros.	Glen Iris Golden Oxford (12694)
Wooroloo Trixie	A.I.S.	23276	4-11-36	11-2-39	180	15	3,795	4·34	165·00	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Capel Shirley's Beauty	do.	19487	18-3-37	3-9-39	150	19·5	4,275	3·85	164·61	B. W. Prowse	Broka Victory (1910)
Colmyn Gold Lady	Jersey	65984	14-8-37	2-8-39	273	7	3,591	4·51	163·80	C. H. Ironmonger ..	Clarendon Eyre Golden Oxford (13606)
Summerlea Joan 4th ..	A.I.S.		28-8-37	30-9-39	210	12	4,110	3·75	154·11	Dunkley Bros.	Leyland's Reward (3331)
Tipperary Fairy 4th	do.		27-11-37	14-9-39	240	5·5	3,225	4·56	147·12	W. G. Burges ..	Blacklands Monarch's Commander (1877)
Wooroloo Opal	do.	23261	8-3-37	23-3-39	210	13·5	3,285	4·57	147·03	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Congelin Noble Lass	Jersey		1-5-37	17-5-39	90	24	2,295	5·42	124·71	B. P. Hack	Clarendon Eyre Eminent's Geishar 4th (13597)
Glanavon Golden Girl 2nd	A.I.S.		22-4-37	7-6-39	90	20	2,160	3·53	76·26	D. Bevan & Sons ..	Parkview Commodore (306)
Claremont Cherry 14th	do		23-10-37	28-1-40	90	21	1,890	3·66	69·30	Claremont Hospital for Insane	Claremont Max Hero (3802)
Brackenhurst Rose 2nd	do.		2-11-37	21-10-39	60	24	1,560	4·35	67·98	B. W. Prowse	Thornleigh Champagne (930)
Claremont Stella 9th ...	do.		17-7-37	19-10-39	60	26·5	1,665	3·89	64·77	Claremont Hospital for Insane	Claremont Herdsman (968)

COWS 2½ YEARS AND UNDER 3 YEARS—STANDARD 250 LBS. BUTTER FAT.

Denmark Rosemary	Guernsey	5451	7-6-36	4-6-39	273	9	7,146	5 65	403 55	Denmark Research Station	Koojan Golden Prosper (2283)
Koojan Ace's Dulcie	do.	5658	6-3-36	25-10-38	273	22 5	6,466	5·74	370·89	A. W. Padbury	Homestead Ace (imp.) (1631)
Grass Vale Buttercup	Jersey	66780	11-9-36	9-9-39	273	19	5,922	5·79	343·23	R. H. Rose	Selsey Gay Boy (15134)
Radyr Park Dorothy 5th	do.	68752	18-7-36	14-7-39	273	11·5	6,050	5·66	339·21	L. Temple	Greenmount Graceful Lad (7292)
Yanget Della 3rd	A.I.S.	23296	1-4-36	17-12-38	273	29	8,667	3·91	338·91	A. E. Grant	Leyland's Defiance (2380)
Crantock Napoleon's Primula 3rd	Jersey	66068	21-6-36	1-5-39	273	11·5	6,050	5·53	334·61	Mrs G H Burnside	Crantock Blonde's Napoleon (8207)
Wattle Creek Star	A.I.S.		3-3-37	15-9-39	273	22	7,296	4·55	332 27	E. T. Thatcher	Yanget Autumn Sun (3630)
Grass Vale Nora Lady	Jersey	66788	1-12-36	11-6-39	273	10·5	5,216	6·20	323·43	R. H. Rose	Selsey Gay Boy (15134)
Wooroloo Doreen	A.I.S.	23238	7-2-37	20-8-39	273	17	7,506	4 31	323 40	Wooroloo Sanatorium Farm	Wooroloo Duke 6th (3622)
Namder Daphne ..	do.	68205	27-10-36	24-9-39	273	12	5,436	5·84	317 31	H. S. Redman	Ventonia Elvira's Masterpiece (13325)
Brookfields Golden Queen 3rd	Guernsey	5324	16-3-36	3-3-39	273	20	6,120	5 15	315 18	P. G. Hampshire	Koojan Ace's Majestic (2735)
Wooroloo Freda 2nd	A.I.S.	23245	9-10-35	21-5-39	240	13	7,380	4 26	314 37	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Grass Vale Golden Cream 15th	Jersey	66783	3-9-36	5-7-39	240	13	5,342	5 82	310·91	R. H. Rose	Selsey Gay Boy (15134)
Denmark Rosette ..	Guernsey	6972	21-7-36	4-6-39	273	10	6,030	5·14	310 15	Denmark Research Station	Koojan Golden Prosper (2283)
The Wold Starbright's Princess	Jersey	64562	4-6-36	15-4-39	273	11 5	5,420	5·63	305·28	L. C. Field	Grantham Air Prince 2nd (10657)
Grass Vale Lady Fowler 24th	do.	66786	4-12-36	9-9-39	273	17 5	5,641	5 37	302·89	R. H. Rose	Selsey Gay Boy (15134)
Glanavon Gem 2nd	A.I.S.		19-10-36	14-4-39	273	24	7,422	4·08	302·64	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Crantock Golden Cream 2nd	Jersey		1-5-36	30-4-39	273	11	6,093	4·95	301·94	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Westby Carnation 3rd .	A.I.S.	23137	25-8-36	13-3-39	273	26	7,608	3·84	292·39	R. J. Morgan	Telyarup Duke 956
Capel Daphne .	do.		20-6-36	18-5-39	273	19·5	7,889	3 64	287·14	B. W. Prowse	Wooroloo Premier 6th (2973)
Grantham Sweet Dreams	Jersey	61955	15-1-36	11-6-39	273	15	5,445	5·17	281·53	J A Sears	Clarendon Eyre Oxford Pioneer (11484)
Radyr Park Estrellita 2nd	do.	68753	26-8-36	19-8-39	273	6 5	4,633	5 93	274·65	L. Temple	Radyr Park Lady's Starlight (13128)
Yanget Snowdrop	A.I.S.	23313	31-5-36	27-12-38	273	22	6,456	4·25	274 39	A. E. Grant	Sunrise of Parkview (1875)
Wooroloo Doris .	do.	23239	4-2-37	11-8-39	273	10	5,805	4 67	270 87	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Capel Noraleda Pretty	Jersey	65870	17-8-36	25-7-39	210	17	5,865	4 62	270 63	B. W. Prowse	Sabina Vale Silver Chief (13223)
Capel Model 2nd	A.I.S.		20-6-36	27-4-39	273	17	6,981	3·86	269 82	B. W. Prowse	Wooroloo Premier 6th (2973)
Westby Lupin 7th .	do.	23140	1-10-36	28-5-39	273	6	6,588	4 09	269 60	R J. Morgan	Telyarup Duke (956)
The Wold Princess Daisy	Jersey	64561	7-8-36	21-7-39	180	14	4,575	5 85	267·48	L. C. Field	Grantham Air Prince 2nd (10657)
Wooroloo Princess .	A.I.S.	23267	7-2-37	20-8-39	273	14	6,192	4 28	265 48	Wooroloo Sanatorium Farm	Wooroloo Duke 6th (3622)
Wooroloo Dessie	do.	23236	25-2-37	29-8-39	273	13	6,009	4·36	261 94	Wooroloo Sanatorium Farm	Wooroloo Duke 6th (3622)
Yanget Milkmaid 5th	do.	23305	19-3-36	4-10-38	273	10	6,960	3 66	256·22	A E. Grant	Sunrise of Parkview (1875)
Colmyn Topsy	Jersey	65991	1-10-36	27-8-39	273	9 5	6,224	4 11	255·59	C. H. Ironmonger	Colmyn Prince Victor (10492)
Capel Cream Sox 2nd	do.	65863	8-10-36	30-6-39	273	12	5,676	4 49	254 99	B W. Prowse	Sabina Vale Silver Chief (13223)
Claremont Blossom 21st	A.I.S		22-9-36	26-3-39	273	20	7,159	3·42	245 69	Claremont Hospital for Insane	Claremont Lyle Earl (3093)
Claremont Poppy 9th	do		2-5-36	8-3-39	273	20	6,488	3 73	241·67	Claremont Hospital for Insane	Claremont Herdsman (968)
Wattle Creek Roany	do.		25-11-36	14-6-39	273	16	6,378	3·77	241 02	E. T. Thatcher	Wooroloo Duchess' Guardian (3621)
Glanavon Pansy 3rd	do.		26-11-36	13-6-39	273	17	6,051	3 98	240 76	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Wattle Creek Rosie	do		1-3-37	15-9-39	273	16	5,898	3 95	232·78	E. T. Thatcher	Yanget Autumn Sun (3630)
Wooroloo Rose 5th .	do	23270	9-11-36	9-10-39	210	11	4,935	4 65	231 45	Wooroloo Sanatorium Farm	Triumph of Pine Creek (2515)
Claremont Flora 3rd	do.		5-8-36	10-4-39	273	15	5,865	3·86	226 74	Claremont Hospital for Insane	Wooroloo Persimmon (2972)

HERD TESTING—*continued.*

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Milk for Last Day.	Milk for Period.	Average Test.	Average Butter Fat.	Owner.	Sire.
COWS 2½ YEARS AND UNDER 3 YEARS—*continued.*											
						lb.	lb.	%	lb.		
Juadine Sparkle 15th	Jersey	67234	23-12-36	7-9-39	273	6	4,543	4·89	222·07	Miss L. G. Hancock	Juadine Paragon (12827)
Summerlea Milkmaid 26th	A.I.S.		4-9-36	16-5-39	273	11	5,973	3·60	216·24	Dunkley Bros.	Greyleigh Asteroid (2184)
Claremont Maggie Morrison 20th	do.		12-7-36	15-4-39	273	17	5,331	4·05	215·82	Claremont Hospital for Insane	Claremont Herdsman (938)
Congelin Velveteen	Jersey	66011	4-12-36	7-9-39	180	12·5	3,960	5·36	212·16	B. P. Hack	Rosecliffe Sybil's Mariposa (9997)
Claremont Cocky 12th	A.I.S.		19-1-37	7-9-39	273	17	5,181	4·08	211·40	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
Claremont Flora 6th	do		5-12-36	20-7-39	273	15	5,385	3·91	210·66	Claremont Hospital for Insane	Claremont Herdsman (968)
Travalgan Lady Eion 2nd	Jersey	59777	29-9-36	25-5-39	273	6·5	3,470	6·01	208·79	Robinson Bros.	Travalgan Northern Noble (10124)
Summerlea Red Rose 9th	A.I.S.		19-5-36	4-5-39	240	15	5,265	3·80	201·29	Dunkley Bros.	Greyleigh Asteroid (2184)
Summerlea Princess 5th	do.		26-5-36	4-5-39	240	2·5	5,550	3·40	189·24	Dunkley Bros.	Greyleigh Asteroid (2184)
Summerlea Jean	do.		22-8-36	1-5-39	210	20·5	5,280	3·50	189·16	Dunkley Bros.	Greyleigh Asteroid (2184)
Westby Polly 4th	do.	23145	30-3-36	11-11-38	210	18	4,590	3·80	176·58	Bayley Bros.	Telyarup Duke (956)
Claremont Whitby Maid 26th	do.		8-8-36	3-4-39	90	21	2,190	3 96	86·79	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
Grantham Oxford Pride	Jersey	66777	9-6-37	12-2-40	60	21	1,440	4·07	58·44	J. A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Congelin Firefly 2nd	do.	66010	3-10-36	28-7-39	30	23	690	4·83	33·33	B. P. Hack	Clarendon Eyre Eminent's Geishar 4th (13597)
COWS 3 YEARS AND UNDER 3½ YEARS—STANDARD 270 LB. BUTTER FAT.											
Travalgan Starbright 3rd	Jersey	59778	1-5-36	6-7-39	273	25	8,340	5·65	471·04	Robinson Brothers	Travalgan Northern Noble (10124)
Greenmount Golden Lass	do.	..	30-9-36	9-10-39	273	14·5	5,614	6·41	424·11	A. J. B. Strempel	Bellefaire Bonaparte's Bonnetienne (9224)
Congelin Rose Marie	do.	61154	5-4-35	12-4-38	273	20·5	6,362	5·61	412·25	B. P. Hack	Rochette's Golden (imp.) (7962)
Wooroloo Moss Rose 4th	A.I.S.	23259	22-4-35	8-10-38	273	23	8,139	4·61	375·54	Wooroloo Sanatorium Farm	Triumph of Pine Creek (2515)
Wooroloo Empress	do.	23241	1-11-35	23-3-39	273	21	8,681	4·13	358·16	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Greenmount Flash Maid	Jersey	61972	28-1-36	18-3-39	273	20	6,600	5·35	353·29	A. J. B. Strempel	Greenmount Golden Flash (12736)
Wooroloo Joy 2nd	A.I.S.	23251	3-8-35	10-1-39	273	24	8,272	4·06	336·19	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Crantock Napoleon's Daisy	Jersey	61210	26-7-35	16-12-38	273	23	6,626	4·81	318·47	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Denmark Annette	Guernsey	5435	17-7-35	4-10-38	273	15	5,228	5·96	311·73	Muresk Agricultural College	Koojan Golden Prosper (2283)
Grantham Air Lady 3rd	Jersey	61950	28-4-36	20-6-39	273	11·5	5,375	5·77	310·07	J. A. Sears	Greenmount Black Prince (6511)
Rutherwood Rosalyn	Guernsey	6264	18-8-35	11-1-39	273	16	5,208	5·85	304·13	Misses Rutherford	Denmark Rosa's Prosper (2639)
Denmark Wild Rose	do.	6974	1-7-36	29-7-39	273	9	6,027	5·05	304·02	Denmark Research Station	Koojan Golden Prosper (2283)
Wooroloo Rose 4th	A.I.S.	23269	2-1-36	29-5-39	273	18	7,074	4·26	301·57	Wooroloo Sanatorium Farm	Triumph of Pine Creek (2515)
The Wold Northwood Crescendo	Jersey	64559	16-4-36	27-4-39	273	9	4,602	6·40	294·43	L. C. Field	Grantham Air Prince 2nd (10657)
Wooroloo Dove 3rd	A.I.S.	23240	4-8-35	26-11-38	210	30	6,900	4·26	293·94	Wooroloo Sanatorium Farm	Parkview Guardian (2557)

Brookfields Lady Charity ...	Guernsey		27-1-36	28-1-39	273	18	4,734	6·19	292·92	P. G. Hampshire	Koojan Ace's Majestic (2735)
Radyr Park Clarionette ...	Jersey	68751	9-2-36	26-7-39	273	8	4,831	6·06	292·77	L. Temple ...	Graceful Lad of Greenmount (7292
Denmark Velda ...	Guernsey	6973	13-7-36	24-7-39	273	8	6,234	4·69	292·52	Denmark Research Station	Denmark Damon (2519)
Brookfields Golden Queen 2nd	do.	5323	10-2-36	2-3-39	273	19	4,992	5·79	289·42	P. G. Hampshire ...	Koojan Ace's Majestic (2735)
Summerlea Joan 2nd ...	A.I.S.	..	2-3-36	7-8-39	273	6	8,523	3·37	287·39	Dunkley Bros. ...	Greyleigh Asteroid (2184)
Gatwick Begum	Jersey		30-3-36	4-9-39	273	13 5	5,246	5·41	283·89	A. J. B. Strempel	Yulelands Stylish Lad (12382)
Denmark Diana	Guernsey	6963	28-6-36	6-7-39	273	8	5,514	5·07	279·78	Denmark Research Station	Denmark Damon (2519)
Denmark Prosperette ..	do.	5446	17-5-36	9-6-39	273	5	5,655	4 83	273 46	Denmark Research Station	Denmark Damon (2519)
Wendowie Quaker ..	do.	6476	11-9-35	18-2-39	210	17	4,980	5·40	269·01	S. F. Russell ..	Muresk Golden Chief (2925)
Yanget Champagne's Lovely	A.I.S.	23294	2-5-36	3-9-39	240	15	6,480	3·89	251·87	A. E. Grant ..	Sunrise of Parkview (1875) (I.M.S.)
Glanavon Doris 3rd	do.	..	14-11-35	4-12-38	273	17	6,051	4 03	243·60	D. Bevan & Sons .	Parkview Commodore (306)
Claremont Laura 7th	do.		8-2-36	26-3-39	273	21	6,258	3 81	238·18	Claremont Hospital for Insane	Claremont Kandor (1964)
Yanget Rudyard Fussy ..	do.	23312	20-9-35	4-10-38	273	13	6,549	3·63	238·02	A. E. Grant ...	Blacklands Lancer (1874)
Claremont Whitby Maid 24th	do.	19618	24-12-35	19-5-39	273	16·5	6,013	3·89	233·37	Claremont Hospital for Insane	Wooroloo Persimmon (2972)
Rutherwood Dame ..	Guernsey	7825	9-7-36	25-8-39	273	8	4,725	4·91	229·83	Misses Rutherford ..	Denmark Damon (2519)
Grantham Oxford's Carnation 2nd	Jersey	61953	20-3-36	23-4-39	273	11 5	5,103	4·46	227·33	J. A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Colmyn Bessie ..	do.	61136	20-5-36	7-10-39	240	11·5	5,160	4·35	224·70	C. H. Ironmonger .	Colmyn Prince Victor (10492)
Wallatin Empress	A.I.S.		5-6-36	20-7-39	273	8	4,768	4·38	208·79	Prowse Bros.	Lemon Grove Myrtle's Heir (1453)
Brackenhurst Dairymaid .	do.	19306	8-11-35	28-4-39	210	19·5	5,475	3·30	180·84	B. W. Prowse .	Thornleigh Champagne (930)
Summerlea Joan 3rd	do.		1-6-36	19-8-39	210	8	5,070	3·52	178·29	Dunkley Bros	Greyleigh Asteroid (2184)
Cloverdowns Madame	do.	19640	20-9-36	22-10-39	210	17	3,915	4·25	166 47	W. G. Burges	Tipperary Melba's Boy (2869)
Yanget Treasure 2nd .	do.	23314	29-4-36	16-8-39	180	14	3,870	4·07	157·86	A. E. Grant	Sunrise of Parkview (1875) (I.M.S.)
Grantham Sweet Dreams 2nd	do.	61956	3-2-37	14-2-40	60	17	1,140	4 36	49·53	J A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Claremont Biddy 32nd	do.		1-3-36	15-8-39	30	39·5	1,185	3·82	45·24	Claremont Hospital for Insane	Claremont Kandor (1964)

COWS 3½ YEARS AND UNDER 4 YEARS—STANDARD 290 LB. BUTTER FAT.

Crantock Cream Duchess 2nd	Jersey	61209	2-8-35	6-8-39	273	25	8,835	6 25	554·31	Mrs. G. H. Burnside .	Crantock Blonde's Napoleon (8207)
Radyr Park Dorothy 4th	do	63850	5-10-35	4-7-39	273	14	8,135	5 41	440·23	L. Temple	Greenmount Graceful Lad (7292)
Tipperary Maggie 4th	A.I.S.	18330	15-9-35	17-7-39	273	27	10,206	4 22	430·90	W. G. Burges	Blacklands Monarch's Commander (1877)
Wooroloo Flash 3rd	do.	23243	1-6-36	18-9-39	273	18	9,249	4 20	388 86	Wooroloo Sanatorium Farm	Parkview Guardian (2557) (A.R.)
Greenmount Golden Marinita	Jersey	61974	29-4-35	30-10-38	273	26·5	7,303	5 16	376·52	A. J. B. Strempel	Bellefaire Bonaparte's Bonetienne (9224)
Crantock Golden Duchess	do.		8-8-35	25-7-39	273	14 5	7,154	5 07	362·96	Mrs. G. H. Burnside .	Crantock Blonde's Napoleon (8207)
Juadine Peerless Lily 9th	do	62336	27-9-35	25-9-39	273	8 5	6,041	5·92	355 69	Miss L. G. Hancock	Juadine Sunshine (8212)
Devonia Silver Queen	do.	66223	18-11-35	18-8-39	273	16	6,363	5 57	354 37	W. Padbury	Sabina Vale Silver Chief (13223)
Denmark Bonnie	Guernsey	5437	22-7-35	21-4-39	273	14	7,302	4 57	333 68	Denmark Research Station	Denmark Damon (2519)
Grass Vale Lady Fowler 21st	Jersey	66784	3-11-35	9-8-39	273	11	6,101	5 39	328 59	R. H. Rose ..	Melrose Lost Key (7974)
Denmark Rose Ophelia	Guernsey	5448	11-7-35	1-7-39	273	12	7,056	4 65	328·48	Denmark Research Station	Koojan Golden Prosper (2283)
Grass Vale Buttercup 2nd	Jersey	66779	22-8-35	9-8-39	273	8·5	5,321	6·09	324 47	R. H. Rose .	Spring Park Starbright's Sweet Duke (8221)
Colmyn Janis 2nd .	do.	61139	12-9-35	6-7-39	273	10	6,203	5·14	318·71	C. H. Ironmonger .	Colmyn Captain Mac (5855)
Claremont Lily 7th .	A.I.S.	19599	17-12-35	16-9-39	273	25	8,385	3·71	310·80	Claremont Hospital for Insane	Wooroloo Persimmon (2972)

HERD TESTING—*continued.*

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test.	No. of Days in Test.	Milk for Last Day.	Milk for Period.	Average Test.	Average Butter Fat.	Owner.	Sire
				COWS 3½ YEARS AND UNDER 4 YEARS—*continued.*							
						lb.	lb.	%	lb.		
Namder Pride	A.I.S.	63313	25-10-35	20-9-39	273	11	5,268	5·85	308·03	H. S. Redman	Grass Vale Choice Star (12732)
Grantham Princess Starbright 3rd	Jersey	57557	20-9-35	17-7-39	273	10	5,610	5·42	304·15	J. A. Sears	Clarendon Eyre Oxford Pioneer (11484)
Westby Pearl 3rd	A.I.S	23143	9-1-36	31-7-39	273	9	8,127	3·74	304·15	Burkitt & Brown	Telyarup Duke (956) (A.R.)
Wallatin Pansy	do.	23058	25-10-35	1-6-39	273	7·5	6,912	4·29	296·45	Prowse Bros.	Lemon Grove Myrtle's Heir (1453)
Glanavon Eva	do.		20-11-35	29-6-39	273	11	7,233	4·00	289·64	D. Bevan & Sons	Villiers of Darbalara (2386)
Grantham Starbright's Queen 3rd	Jersey	57559	9-8-35	17-7-39	273	13	5,314	5·40	286·96	J. A. Sears	Greenmount Black Prince (6511)
Capel Noraleda 2nd	do.	60992	3-8-35	23-6-39	240	14·5	5,160	5·55	286·53	B. W. Prowse	Capel Carnation's Pride (7988)
Claremont Cherry 11th	A.I.S.	19595	30-10-35	26-5-39	273	21	7,188	3·92	281·58	Claremont Hospital for Insane	Claremont Herdsman (968)
Wooroloo Lady Betty 2nd	do.	23254	8-9-35	27-5-39	273	16	6,318	4·44	280·74	Wooroloo Sanatorium Farm	Triumph of Pine Creek (2515)
Glanavon Dell 2nd	do.		26-10-35	2-5-39	273	21	7,668	3·61	276·87	D. Bevan & Sons	Parkview Commodore (306)
Westby Carnation 2nd	do.	18515	12-8-35	30-6-39	273	8	7,118	3·86	274·90	Burkitt & Brown	Telyarup Duke (956)
Glanavon Gem	do.		18-11-35	18-7-39	240	8	6,330	4·27	270·12	D. Bevan & Sons	Glanavon Nimrod (437)
Summerlea Hobby 13th	do.		2-5-35	3-5-39	273	14·5	7,513	3·50	263·08	Dunkley Bros.	Summerlea Togo (1527)
Colmyn Peggy	Jersey	61141	26-10-35	30-7-39	273	7	5,691	4·14	235·90	C. H. Ironmonger	Colmyn Captain Mac (5855)
Grantham Easter Rye 4th	do.	57554	18-10-35	8-8-39	210	12·5	3,983	5·90	235·74	J. A. Sears	Greenmount Black Prince (6511)
Wallatin Fairy	A.I.S.	23056	21-9-35	16-6-39	273	15	5,700	4·05	231·13	Prowse Bros.	Lemon Grove Myrtle's Heir (1453)
Yanget Lady Thelma	do.	22302	17-3-35	4-10-38	273	[illegible]	6,228	3·67	228·89	A. E. Grant	Tipperary Topsy's Monarch (2875)
Summerlea Swallow 8th	do.	..	27-10-35	15-7-39	210	12	6,060	3·62	219·27	Dunkley Bros.	Summerlea Togo (1527)
Crantock Napoleon's Primula 2nd	Jersey	61211	7-7-35	16-3-39	210	14·5	3,743	5·76	215·46	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Capel Princess	A.I.S.	19486	22-9-35	13-5-39	210	11	5,370	4·00	214·14	B. W. Prowse	Wooroloo Premier VI. (2973)
Summerlea Milkmaid 21st	do	.	24-10-35	9-8-39	273	9	5,682	3·77	213·95	Dunkley Bros.	Summerlea Togo (1527)
Summerlea Milkmaid 20th	do.		11-10-35	6-8-39	210	10·5	4,995	3·66	183·03	Dunkley Bros.	Summerlea Togo (1527)
Capel Model	do.	19485	2-8-35	29-5-39	180	15	4,425	3·85	170·31	B. W. Prowse	Thornleigh Champagne (930)
Tipperary Lofty 3rd	do.	22909	2-11-35	29-5-39	90	40	4,020	3·99	159·96	W. G. Burges	Blacklands Monarch's Commander (1877)
Congelin Firefly	Jersey	66009	5-9-35	27-4-39	120	24·5	2,940	5·34	156·93	B. P. Hack	Clarendon Eyre Oxford Dreamer (imp. in dam) (10273)
Moorlands Janie	do.		16-11-35	14-8-39	90	20	2,205	6·53	144·00	Estate late P. Rose	Melrose Liberty (7973)
				COWS 4 YEARS AND UNDER 4½ YEARS—STANDARD 310 LB. BUTTER FAT.							
Koojan Ace's Jewel 2nd	Guernsey	5661	4-3-35	20-8-39	273	42	13,169	5·19	683·45	A. W. Padbury	Homestead Ace (1631)
Denmark Dawn 2nd	do.	5439	21-3-35	26-7-39	273	17	8,571	6·01	514·70	Denmark Research Station	Koojan Golden Prosper (2283)
Wooroloo Bonnie	A.I.S.	18626	29-10-34	24-3-39	273	31	11,373	4·25	483·24	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Greenmount Golden Wonder	Jersey	61975	28-3-35	21-8-39	273	18	8,581	5·36	460·99	A. J. B. Strempel	Bellefaire Bonaparte's Bonetienne (9224)
Greenmount Gentle Lady	do.	61973	8-8-35	3-10-39	273	17	7,371	6·14	452·98	A. J. B. Strempel	Bellefaire Bonaparte's Bonetienne (9224)
Tipperary Dove 2nd	A.I.S.	18321	9-7-34	21-10-38	273	27·5	11,686	3·71	433·12	B. W. Prowse	Parkview Rosie's Monarch (1681)
Norric Peggy	do.	...	14-4-35	8-7-39	273	15	10,575	4·07	429·94	W. G. Burges	Warwick Rufus (3595)
Yanget Victress	do.	18662	29-7-35	16-9-39	273	23	9,969	4·20	419·49	A. E. Grant	Sunrise of Parkview (1875)

Wooroloo Dell	do.	18628	18-10-34	23-3-39	273	28	10.419	4·01	418·10	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Tipperary Sally	do.	18338	23-4-35	31-5-39	273	23	10.929	3·82	417·02	W. G. Burges	Blacklands Monarch's Commander (1877)
Glanavon Fairy	do.	20204	22-12-34	24-6-39	273	27	10.131	4·09	415·19	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Glanavon Tiny	do.	20212	25-9-34	19-3-39	273	24	9,462	4·32	408·37	D. Bevan & Sons	Blacklands Jean's Supreme (1871)
Coogely Zonia	Guernsey	5430	4-7-34	18-10-38	273	25·5	7,862	5·18	407·08	A. W. Padbury	Koojan Fortywinks (2738)
Yanget Melba	A.I.S.	23304	12-5-35	19-9-39	273	22	9.216	4·34	400·58	Wooroloo Sanatorium Farm	Parkview Sunrise (1875)
Congelin Rose Marie 2nd	Jersey	61155	2-5-36	2-6-39	273	12	6,276	5·76	390·44	B. P. Hack	Clarendon Eyre Oxford Gamboge (10274)
Colmyn Brown Maggie	do.	56859	27-6-35	4-8-39	273	12·5	7.133	5·25	374·22	C. H. Ironmonger	Colmyn Prince Victor (10492)
Brookfields Mignonette	Guernsey	5329	18-6-35	2-7-39	273	10	7.237	5·02	363·70	W. Darnell	Koojan Lord Barklay (1031)
Congelin Iolanthe	Jersey	61152	27-3-35	13-4-39	273	19·5	8,264	4·35	360·14	B. P. Hack	Rochette's Golden (imp.) (7962)
Wooroloo Fairy 2nd	A.I.S.	18631	3-12-34	3-5-39	273	17	9.811	3·63	356·37	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Brookfields Bonnie Blossom	Guernsey	5319	15-8-34	15-10-38	273	18·5	6,926	5·10	353·37	W. Darnell	Koojan Lord Barklay (1031)
Westby Carnation	A.I.S.	18514	30-5-35	28-8-39	273	14	9,349	3·76	351·37	Burkitt & Brown	Telyarup Duke (956)
Denmark Irish Rosette	Guernsey	5442	27-3-35	5-7-39	273	12·5	7.238	4·84	350·12	Misses Rutherford	Denmark Damon (2519)
Denmark Atalie	do.	5436	23-6-34	6-12-38	273	22	6,336	5·48	347·39	Misses Rutherford	Koojan Golden Prosper (2283)
Tipperary Dove 4th	A.I.S.	18323	18-7-35	9-8-39	273	20	7,770	4·31	334·96	W. G. Burges	Blacklands Monarch's Commander (1877)
Rosy Hill Pansy	Jersey	59328	6-2-35	9-7-39	273	14	5,322	6·01	320·13	M. T. Padbury	Spring Park Starbright's Sweet Duke (8221)
Crantock White Stockings	do.	56955	9-4-35	21-9-39	273	7·5	8,671	3·68	319·54	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Congelin Tangerine	do.	61156	13-6-35	15-7-39	273	11	6,237	5·11	318·95	B. P. Hack	Clarendon Eyre Oxford Gamboge (10274)
Greenmount Golden Dewdrop	do.	57569	7-8-34	20-1-39	210	24	5.250	5·83	305·88	A. J. B. Strempel	Bellefaire Bonaparte's Bonetienne (9224)
Brookfields Primrose	Guernsey	5331	24-2-35	20-6-39	240	9	5,910	5·02	296·73	W. Darnell	Koojan Ace's Majestic (2735)
Rosy Hill Venus	Jersey	64111	27-8-35	19-9-39	273	8	5.124	5·78	295·91	M. T. Padbury	Rosy Hill Pearl's Chief (12136)
Leylands Champagne's Lovely	A.I.S.	12249	5-6-34	7-11-38	273	17	7,611	3·87	294·66	A. E. Grant	Thornleigh Champagne (930)
Yanget Della 2nd	do.	15409	3-5-34	13-10-38	273	12	7,581	3·88	294·11	A. E. Grant	Sunrise of Parkview (1875)
Yanget Florrie	do.	18653	18-3-35	1-9-39	210	22·5	7,560	3·82	289·09	A. E. Grant	Sunrise of Parkview (1875)
Wendowie Empress	Guernsey	8082	17-2-35	12-3-39	210	17	5,250	5·06	265·44	S. F. Russell	Koojan Lord Barklay (1031)
Norric Daisy Bell	A.I.S.		23-4-35	2-9-39	210	16	6,510	4·05	263·58	W. G. Burges	Warwick Rufus (3505)
Radyr Park Melody	Jersey	59126	26-1-35	2-3-39	273	13·5	4,376	5·83	255·12	L. Temple	Graceful Lad of Greenmount (7292)
The Wold Air Daisy	do.	59710	26-4-35	24-7-39	210	5	4,995	4·66	232·86	L. C. Field	Grantham Air Prince 2nd (10657)
Moorlands Janet	do.		25-3-35	17-7-39	120	25·5	3.945	4·71	185·85	Estate late P. Rose	Preston Prospector (11024)
Summerlea Dairymaid 21st	A.I.S.		2-8-35	25-8-39	210	14	5,055	3·50	177·15	Dunkley Bros.	Summerlea Togo (1527)
Moorlands Jolly	Jersey		28-3-35	3-7-39	120	27·5	3,750	4·69	176·10	Estate late P. Rose	Preston Prospector (11024)
Grass Vale Lady Fowler 20th	do.	61959	29-5-35	17-8-39	60	32	2.910	5·27	115·35	R. H. Rose	Spring Park Starbright's Sweet Duke (8221)

COWS 4½ YEARS AND UNDER 5 YEARS—STANDARD 330 LB. BUTTER FAT

Travalgan Starbright 2nd	Jersey	55608	4-9-34	30-5-39	273	25	8,445	5·45	460·87	Robinson Bros.	Travalgan Northern Noble (10124)
Glanavon Vera	A.I.S.	16494	14-1-34	7-1-39	273	28	6,804	5·90	401·22	E. T. Thatcher	Glanavon Nimrod (437)
Juadine Sparkle 11th	Jersey	57870	14-8-34	26-4-39	273	21	8,223	4·27	351·05	B. P. Hack	Juadine Sunshine (8212)
Crantock Cream Duchess	do.	56952	15-9-34	14-6-39	273	18·5	6,836	5·10	349·09	Mrs. G. H. Burnside	Crantock Blonde's Napoleon (8207)
Brookfields Glory	Guernsey	4059	15-3-34	24-1-39	273	24	6,492	5·23	340·02	P. G. Hampshire	Koojan Ace's Chancellor (2274)
Brookfields Lady Lynette	do.	5327	21-7-34	12-6-39	273	10	6,945	4·78	332·59	W. Darnell	Koojan Lord Barklay (1031)
Colmyn Violet	Jersey	52322	6-10-34	8-8-39	273	9	6,537	5·01	327·82	C. H. Ironmonger	Colmyn Prince Victor (10492)
Glanavon Sunbeam 6th	A.I.S.	20211	8-11-34	28-7-39	273	16	6,788	4·80	325·82	D. Bevan & Sons	Glanavon Nimrod (437)
Brookfields Lady Hope	Guernsey	5325	14-9-34	11-6-39	273	11	6,438	5·00	322·47	W. Darnell	Koojan Lord Barklay (1031)
Rutherwood Rosette	do.	6265	23-8-34	19-7-39	273	11·5	6,005	5·34	320·25	Misses Rutherford	Denmark Rosa's Prosper (2639)

HERD TESTING—*continued.*

Name of Cow.	Breed.	Herd Book No.	Date of Birth.	Date of Entry to Test	No. of Days in Test.	Milk for Last Day.	Milk for Period.	Average Test.	Average Butter Fat.	Owner.	Sire.
COWS 4½ YEARS AND UNDER 5 YEARS—*continued.*											
						lb.	lb.	%	lb.		
The Wold Merry Daisy ..	Jersey	55528	14-8-34	13-5-39	273	11	5,388	5·85	314·94	L. C. Field	Merry King of Greenmount (4306)
Moorlands Italy .. .	do.	68074	20-7-34	15-3-39	240	19·5	5,745	5·33	306·24	Estate late P. Rose	Melrose Liberty (7973)
Capel Gladys Queen	do.	60990	21-9-34	27-6-39	240	15	5,715	5·16	295·16	B. W. Prowse ..	Capel Carnation's Pride (7988)
Grass Vale Molly's Nora .	do.	57561	9-8-34	30-6-39	240	15·5	5,439	5·37	292·14	R. H. Rose	Banyule Silvermine's Twylish (7600)
Moorlands Iliad . .	do.		12-6-34	21-3-39	210	16	4,598	5·70	262·00	Estate late P. Rose ..	Melrose Liberty (7973)
Capel Pretty	do.	56710	16-8-34	22-5-39	210	17	4,905	4·41	215·19	B. W. Prowse	Devonia Makarina (8217)
Summerlea Sheila 3rd ...	A.I.S.	22529	21-3-35	19-10-39	210	7·5	5,940	3·60	213·96	Dunkley Bros.	Summerlea Togo (1527)
COWS 5 YEARS AND OVER—STANDARD 350 LB. BUTTER FAT.											
Blacklands Ettie 9th ..	A.I.S.	9298	24-9-32	18-9-39	273	51	17,523	4·43	776·91	D. Bevan & Sons	Parkview Limelight (370)
Koojan Lady Olive ...	Guernsey	4340	11-2-33	12-9-39	273	34·5	11,369	5·39	612·28	A. W. Padbury	Homestead Ace (imp.) (1631)
Beauna Vista Fairy 5th .	A.I.S.	1322	8-12-29	19-5-39	273	41	16,653	3·67	610·21	Prowse Bros. .	Spearfelt of Alne Bank (1029)
Koojan Ace's Jewel ..	Guernsey	4333	19-2-33	22-4-39	273	34	11,067	5·42	600·05	A. W. Padbury	Homestead Ace (imp.) (1631)
Koojan Golden Butterfly	do.	4339	18-4-33	1-5-39	273	32·5	10,223	5·49	561·57	A. W. Padbury	Koojan Ace (2270)
Koojan Ace's Pixie	do.	4336	11-4-33	15-9-39	273	33	10,825	5·14	555·88	A. W. Padbury ...	Homestead Ace (imp.) (1631)
Travalgan Lady Mint 4th	Jersey	55607	11-4-34	8-5-39	273	22	9,156	5·83	533·81	Robinson Bros.	Banyule Altitude (5793)
Denmark Rosebud	Guernsey	3876	14-3-32	20-4-39	273	29	8,937	5·89	525·56	Denmark Research Station	Wollongbar MacQuarrie
Newstead Lovely 20th	A.I.S.	17585	19-2-34	6-5-39	273	34	12,297	4·17	513·15	W. G. Burges	Renown of Newstead (3077)
Tipperary Beauty 2nd ...	do.	18314	8-9-34	1-8-39	273	21	12,003	4·19	502·72	W. G. Burgess .	Blacklands Monarch's Commander (1877)
Blacklands Pretty Maid 6th	do.	9376	25-2-32	13-7-39	273	20	11,305	4·10	463·75	A. E. Grant . .	Orama of Blacklands (1905)
Denmark Golden Marie	Guernsey	3873	26-4-32	29-7-39	273	8	8,064	5·55	447·70	Denmark Research Station	Koojan Golden Prosper (2283)
Wooroloo Gold	A.I.S.	18632	31-1-34	2-7-39	273	26	11,133	4·00	445·47	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Crantock Napoleon's Duchess	Jersey	52399	11-1-34	29-9-39	273	12	8,121	5·36	435·40	H. S. Redman	Crantock Blonde's Napoleon (8207)
Denmark Golden Dawn ..	Guernsey	4118	9-1-33	27-4-39	273	20	7,080	6·17	436·82	Denmark Research Station	Koojan Golden Prosper (2283)
Wooroloo Milkmaid 5th ...	A.I.S.	15339	2-1-34	5-3-39	273	26	11,058	3·93	434·75	E. T. Thatcher ..	Parkview Guardian (2557)
Lemon Grove Gladys 10th	do.	17147	14-8-33	28-6-39	273	20	11,078	3·85	426·47	Prowse Bros. . .	Dan of Greyleigh (97)
Lemon Grove Fussy 6th .	do.	17144	10-5-33	20-6-39	273	17	10,551	4·00	422·73	Prowse Bros.	Alne Bank Lady's Gift (760)
Denmark Prosper's Rosa	Guernsey	4127	27-12-32	29-4-39	273	20	7,560	5·48	414·63	Denmark Research Station	Koojan Golden Prosper (2283)
Muresk Dessie	do.	4722	20-4-33	28-5-39	273	22	7,926	5·23	414·46	Muresk Agricultural College	Triumph of Wollongbar (513)
Illawah Lex 3rd	A.I.S.	11797	15-2-33	8-7-39	273	31	10,983	3·75	412·31	D. Bevan & Sons	Illawah Veteran's Hope (822)
Greenmount Sweet Lass ...	Jersey	44204	14-7-33	18-3-39	273	21·5	7.408	5·57	412·02	A. J. B. Strempel . .	Bellefaire Bonaparte's Bonetienne (9244)
Crantock Cream Lass	do.	43542	7-6-31	28-6-39	273	11	7,383	5·54	408·85	Mrs. G. H. Burnside ..	Crantock Starbright's Montrose (5945)
Denmark Orangebud ..	Guernsey	4123	9-8-32	17-10-38	273	24	8,892	4·42	405·32	Denmark Research Station	Koojan Golden Prosper (2283)
Wooroloo Duchess 2nd	A.I.S.	15324	15-8-32	25-6-39	273	21	10.263	3·93	405·12	E. T. Thatcher . .	Triumph of Pine Creek (2515)
Beauna Vista Tiny 18th	do.	4221	24-6-30	6-6-39	273	18	10,626	3·75	398·52	Prowse Bros.	Spearfelt of Alne Bank (1029)

Milbank Joan 4th ...	do.	4976	7-5-31	28-8-39	210	9·5	9.39	4·22	397·05	Dunkley Bros.	Parkview Ruler (309)
Capel Glad Star ...	Jersey	47538	14-12-32	22-5-39	273	26·5	8,315	4·74	394·19	B. W. Prowse	Capel Carnation's Pride (7988)
Radyr Park Dorothy ..	do.	45844	27-7-31	25-7-39	240	15	8,010	4·88	391·10	L. Temple	Melrose Clarion (6931)
Greenmount Bonetienne's Twinklette	do.	44202	6-8-33	25-11-38	273	18·5	6,581	6·00	390·17	A. J. B. Strempel	Bellefaire Bonaparte's Bonnetienne (9244)
Muresk Lady Fair	Guernsey	4729	20-9-32	11-5-39	273	18·5	8,090	4·78	386·75	Muresk Agricultural College	Triumph of Wollongbar (513)
Brackenhurst Treasure 2nd	A.I.S.	15755	16-7-33	12-6-39	273	16	9,618	4·00	385·55	R. J. Morgan	Tipperary Royal's Re-echo (964)
Muresk Damsel ..	Guernsey	4720	2-11-33	28-2-39	273	22	7,701	4·97	383·07	Muresk Agricultural College	Muresk Homestead (2075)
Lansdowne Bonnie Blossom 2nd	do.	4351	6-8-33	6-8-39	273	14	7,542	4·89	374·99	J. R. Giles ..	Koojan Ace's Advocate (2272)
The Wold Easter Daisy	Jersey	34731	5-6-31	27-4-39	273	14·5	7,004	5·34	374·00	L. C. Field	Grantham Easter King (6510)
Rosy Hill Pearl	do.	24707	5-9-25	13-9-39	273	18	7,284	5·11	372·59	M. T. Padbury	Choice Goods of Garden Hill (4580)
Lemon Grove Gracie 11th	A.I.S.	17148	10-8-33	1-6-39	273	18	9,467	3·93	371·87	Prowse Bros.	Greyleigh Archer (571)
Spring Park Starbright 2nd	Jersey	23658	17-10-26	6-5-39	273	16	6,483	5·73	371·28	M. T. Padbury	Rye Duke of Glen Iris (1994)
Leylands Tiny ..	A.I.S.	17181	24-2-34	25-5-39	273	15	9,795	3·77	369·29	Prowse Bros.	Parkview Commodore (306)
Illawah Limerick Lass 2nd	do.	5016	14-9-29	9-6-39	273	6	9,993	3·68	368·10	Prowse Bros	Sentinel of Greyleigh (1647)
Coogely Princess	Guernsey	4103	25-11-32	4-8-39	273	15	7,335	5·00	366·60	S. F. Russell	Karridale Laddie (1440)
Devonia Starbright's Fancy	Jersey	43631	20-9-32	17-7-39	273	10	6,375	5·74	366·05	W. Padbury	Grantham Starbright's King (5796)
Westby Lupin 3rd	A.I.S.	18156	31-8-34	16-9-39	273	10	9,443	3·83	362·02	Burkitt & Brown	Telyarup Duke (956)
The Wold Starbright Daisy	Jersey	31179	8-7-30	9-5-39	273	14	6,912	5·28	365·00	L. C. Field	Grantham Starbright's King (5796)
The Wold Starbright Grey 2nd	do.	46430	17-4-33	4-6-39	273	15	7,950	4·54	360·95	L. C. Field	Lonswood Lord Grey (7291)
Capel Noraleda	do.	56709	7-3-34	15-5-39	273	22	7,341	4·92	360·90	B. W. Prowse	Capel Carnation's Pride (7988)
Minnamurra Orvieto	Guernsey	1597	4-8-26	11-9-39	273	10	7,620	4·69	357·83	P. G. Hampshire	Minnamurra Golden Lad (402)
Tabbagong Dove 11th	A.I.S.	14421	22-7-33	25-4-39	273	12	8,376	4·26	357·26	W. G. Burges	Parkview Reward 2nd (260)
Lansdowne Lassie ...	Guernsey	4362	8-4-33	7-7-39	273	15	7,095	5·03	357·00	J. R. Giles	Woodstock Ace (2118)
The Wold Northwood Grey	Jersey	42214	15-5-32	20-4-39	273	14·5	6,974	5·09	355·40	L. C. Field	Lonswood Lord Grey (7291)
Radyr Park Clarion Call	do.	45843	5-7-31	18-8-39	273	10	6,195	5·73	355·11	L. Temple	Melrose Clarion (6931)
Crantock Lady Buttercup	do	39439	21-5-30	9-9-39	273	14	6,312	5·62	354·97	Mrs. G. H. Burnside	Crantock Starbright's Montrose (5945)
Grass Vale Twylish Eve	do.	61960	17-10-33	7-5-39	273	16	6,378	5·53	352·55	R. H. Rose	Banyule Silvermine's Twylish (7600)
Lemon Grove Dora 8th	A.I.S.	17141	12-12-33	10-5-39	273	18	9,234	3·80	351·90	Prowse Bros.	Dan of Greyleigh (97)
Grass Vale Golden Cream 9th	Jersey	61958	16-8-33	29-5-39	273	13	5,637	6·17	348·20	R. H. Rose	Banyule Silvermine's Twylish (7600)
Grass Vale Noramine	do	48537	17-11-33	29-5-39	273	14·5	6,011	5·79	348·00	R. H. Rose	Banyule Silvermine's Twylish (7600)
Tipperary Daphne ..	A.I.S.	5114	5-10-30	24-7-39	273	14	8,712	3·99	347·65	B. W. Prowse	Melba's Re-echo of Darbalara (2452)
Blacklands Fairy 12th	do.	9301	6-5-37	10-4-39	273	20	9,060	3·82	346·45	D. Bevan & Sons	Orama of Blacklands (1905)
Denmark Orangebud	Guernsey	4123	9-8-32	20-9-39	273	23	7,479	4·62	345·86	Denmark Research Station	Koojan Golden Prosper (2283)
Numbawarra Silky 3rd	A.I.S.	17626	28-8-32	25-7-39	273	16	9,190	3·75	345·03	Prowse Bros	Jellicoe of Fairfield (1136)
Beauna Vista Jock's Tiny	do	9075	25-9-32	10-4-39	273	23	9,579	3·52	343·80	D. Bevan & Sons	Beauna Vista Jock (212)
Selsey Attraction	Jersey	55203	16-7-34	11-8-39	180	20	5,520	6·21	343·02	Robinson Bros.	Brampton Great Boy (imp.) (9137)
Leylands Princess	A.I.S.	12255	21-10-33	11-6-39	273	15	8,265	4·12	340·81	B. W. Prowse	Mayflower's Emblem of Hillview (955)
Westby Ulery	do.	15143	15-6-33	26-8-39	273	8	9,129	3·73	340·81	Burkitt & Brown	Telyarup Duke (956)
Lemon Grove Pride 8th	do.	17150	20-7-33	11-5-39	273	9	8,937	3·74	334·74	Prowse Bros.	Alne Bank Lady's Gift (760)
Denmark Prosper's Mona	Guernsey	4126	2-2-33	6-6-39	273	20·5	7,367	4·48	330·49	Muresk Agricultural College	Koojan Golden Prosper (2283)
Tabbagong Beauty 19th	A.I.S.	7502	20-12-37	7-5-39	240	14·5	8,307	3·96	329·00	A. E. Grant	Parkview Reward 2nd (260)
Blacklands Miss Tottie 4th	do.	9365	12-4-32	20-10-38	273	14	7,602	4·25	322·59	A. E. Grant	Orama of Blacklands (1905)
Radyr Park Dorothy 2nd	Jersey	45845	24-7-32	26-7-39	240	14·5	5,858	5·49	322·06	L. Temple	Graceful Lad of Greenmount (7292)
Karridale Girlie	Guernsey	3820	24-9-30	23-12-38	273	21	6,108	5·17	315·81	P. G. Hampshire	Minnamurra Rose Chief (1016)
Westby Lupin 2nd	A.I.S.	15139	6-9-33	17-11-38	210	30	8,100	3·81	308·25	Bayley Bros.	Telyarup Duke (956)
Summerlea Milkmaid 12th	do	18130	9-5-33	20-8-39	273	5	7,080	4·32	306·14	Dunkley Bros.	Summerlea Searchlight (972)
Summerlea Milkmaid 7th	do.	7683	3-1-31	20-7-39	273	8	8,859	3·42	302·58	Dunkley Bros.	Victor of Telyarup (2498)

HERD TESTING—*continued.*

Name of Cow.	Breed	Herd Book No.	Date of Birth.	Date of Entry to Test	No. of Days in Test.	Milk for last Day	Milk for Period.	Average Test.	Average Butter Fat.	Owner.	Sire.
				COWS 5 YEARS AND OVER—*continued.*							
						lb.	lb.	%	lb.		
Crantock Napoleon's Primula	Jersey	56957	17-7-34	26-9-39	273	12	5,976	5·04	302·18	H. S. Redman	Crantock Blonde's Napoleon (8207)
Leylands Daphne	A.I.S.	12252	2-8-33	29-8-39	210	19	7,575	3·97	300·72	B. W. Prowse	Widgee Waa Record (848)
Denmark Prosper's Lady	Guernsey	3273	6-12-31	24-4-39	273	16	5,598	5·37	300·50	Denmark Research Station	Koojan Golden Prosper (2283)
Swanlea Radium 8th	A.I.S.	4990	17-7-31	21-5-39	273	14	8,232	3·63	299·08	Prowse Bros.	Headlight of Parkview (1406)
Blacklands Daphne 7th	do.	9291	18-10-32	5-4-39	273	20·5	8,747	3·38	295·63	A. E. Grant	Fussy's Monarch of Hill View (493)
Yanget Duchess 2nd	do	15410	10-5-34	12-7-39	240	16	8,355	3·49	291·40	A. E. Grant	Sunrise of Parkview (1875)
Leyland's Model	do.	12254	12-8-33	13-7-39	240	9	7,740	3·76	291·31	B. W. Prowse	Widgee Waa Record (848)
Blacklands Graceful 7th	do.	9318	24-7-32	5-9-39	240	18	6,975	4·17	291·30	A. E. Grant	Orama of Blacklands (1905)
Minnamurra Currency Lass	Guernsey	2606	27-10-29	17-7-39	273	9	6,312	4·58	288·90	Muresk Agricultural College	Caramana Favour (652)
Greenmount Marinette	Jersey	34840	24-5-31	15-12-38	273	21	5,913	4·81	288·20	A. J. B. Strempel	Grantham Starbright King (5796)
Grass Vale Buttercup	do.		28-6-31	27-6-39	240	11·7	4,821	5·95	287·11	R. H. Rose	Campanile's Duke of Burekup (7237)
Blacklands Modesty 3rd	A.I.S.	9367	20-5-32	5-10-38	273	24	7,362	3·85	283·71	A. E. Grant	Emperor of Blacklands (947)
Crantock Starbright's Duchess	Jersey	39440	15-10-30	20-7-39	273	12	5,331	5·27	281·19	Mrs. G. H. Burnside	Crantock Starbright's Chief (5790)
Summerlea Red Rose 3rd	A.I.S.	14253	24-5-31	7-8-39	240	11·5	7,073	3·97	280·68	Dunkley Bros.	Summerlea Searchlight (972)
Colmyn Bubbles	Jersey	47678	21-9-33	27-8-39	273	5·5	6,047	4·58	277·20	C. H. Ironmonger	Colmyn Captain Mac (5855)
Summerlea Tulip 13th	A.I.S	22531	14-7-34	9-8-39	240	8	7,485	3·62	270·90	Dunkley Bros.	Summerlea Togo (1527)
Garden Hill Silvermine 7th	Jersey	48173	29-9-33	20-5-39	273	10	5,145	5·18	266·39	M. T. Padbury	Glen Iris Star (9492)
Crantock Lady Primrose	do.	52398	10-6-31	23-8-39	180	21	6,015	4·41	265·11	Mrs. G. H. Burnside	Crantock Starbright's Montrose (5945)
Yanget Pendant 2nd	A.I.S.	15415	29-6-33	18-12-38	273	16	6,738	3·82	257·32	A. E. Grant	Yanget Lucky Boy (978)
Garden Hill Golden Princess	Jersey	43921	14-12-32	12-10-39	273	11	4,248	6·05	257·15	W. Padbury	Glen Iris Star (9492)
Karrawang Nancy 5th	A.I.S.	4246	26-4-30	10-9-39	273	8	7,005	3·61	253·02	Dunkley Bros.	Standard of Cosy Camp (2695)
Colmyn Eileen	Jersey	43463	8-10-32	1-10-39	240	10	6,570	3·83	251·84	C. H. Ironmonger	Rye Duke of Glen Iris (1994)
Summerlea Beauty 7th	A.I.S.	22520	10-7-34	8-8-39	273	8·5	6,656	3·76	250·63	Dunkley Bros.	Summerlea Supreme (973)
Summerlea Dairymaid 8th	do.	14242	19-12-31	9-7-39	240	8	7,170	3·49	250·50	Dunkley Bros.	Victor of Telyarup (2498)
Glanavon Vida 2nd	do	16495	25-5-33	28-11-38	273	24	6,180	4·05	250·29	E. T. Thatcher	Glanavon Nimrod (437)
The Wold Daisy Grey 2nd	Jersey	46428	28-3-33	1-7-39	240	5·5	4,980	4·99	249·48	L. C. Field	Lonswood Lord Grey (7291)
Moorlands Glide	do.	45237	5-8-32	15-6-39	150	25	4,740	5·23	247·74	Estate late P. Rose	Melrose Clarion (6931)
Moorlands Happy	do	54219	30-4-33	20-3-39	150	23·5	4,605	5·34	245·58	Estate late P. Rose	Melrose Liberty (7973)
Grass Vale Golden Cream 7th	do.	44182	19-7-32	17-8-39	210	13·5	4,410	5·56	245·26	R. H. Rose	Banyule Silvermine's Twylish (7600)
Yanget Royal Lady	A.I.S	15417	21-9-33	5-10-38	273	16	6,648	3·67	243·71	A. E. Grant	Glanavon Defender (959)
Capel Centenary Girl 3rd	Jersey	56707	3-3-34	14-8-39	210	14·5	4,875	4·95	241·29	B. W. Prowse	Capel Carnation's Pride (7988)
Lemon Grove Buttercup 25th	A.I.S.	17136	25-7-33	7-7-39	273	12	6,236	3·84	239·26	Prowse Bros.	Alne Bank Lady's Gift (760)
Summerlea Betty 3rd	do	14239	9-3-32	18-9-39	240	6	5,655	4·10	231·87	Dunkley Bros.	Summerlea Searchlight (972)
Summerlea Hobby 11th	do	18128	4-5-34	13-8-39	273	10	7,080	3·24	229·64	Dunkley Bros	Summerlea Kitchener (971)
Blacklands Lady Thelma 7th	do	9342	1-11-32	19-11-38	273	5	5,325	4·28	228·28	A. E. Grant	Parkview Limelight (370)
Grass Vale Twylish Maggie	Jersey	53029	12-6-33	12-8-39	210	12	4,565	4·89	223·31	R. H. Rose	Banyule Silvermine's Twylish (7900)
Mokine Sapphire 2nd	do.	49584	20-10-32	31-8-38	180	19	4,290	4·66	199·95	Miss L. Hancock	Juadine Sunshine (8212)
Denmark Rosa 3rd	Guernsey	2523	5-4-29	15-9-39	150	13	4,290	4·64	199·17	Denmark Research Station	Wollongbar Reformer (538)
Grass Vale Lady Fowler 16th	Jersey	44183	2-9-32	3-9-39	210	6	3,385	5·68	192·51	R. H. Rose	Banyule Silvermine's Twylish (7600)
Westby Polly	A.I.S.	15141	21-5-32	19-2-39	120	35	4,440	4·17	185·19	Bayley Bros.	Telyarup Duke (956)
Marks Villa Lottie 3rd	do.	16484	10-11-28	8-9-39	60	58·5	3,825	3·68	140·76	B. W. Prowse	Marks Villa Dina's Lad

Radyr Park Laddie's Estrellita	Jersey	45846	16-7-32	31-7-39	90	33	2.595	5·27	136·92	L. Temple	Graceful Lad of Greenmount (7292)
Moorlands Haven	do.		27-6-33	29-8-39	90	30·5	2,760	4·68	129·15	Estate late P. Rose	Melrose Liberty (7973)
Wooroloo Joy	A.I.S.	15333	10-4-34	28-8-39	60	50	3,300	3·91	129·06	Wooroloo Sanatorium Farm	Parkview Guardian (2557)
Capel Daisy 2nd . . .	Jersey	34349	22-12-39	13-8-39	120	18	2,790	4·61	128·70	B. W. Prowse	Bracken Fern of Roelands (4014)
Grass Vale Lady Fowler 17th	do.	48536	6-5-33	8-5-39	60	30·5	2,190	5·19	113·55	R. H. Rose . ..	Banyule Silvermine's Twylish (7600)
Leyland's Lady Betty ...	Guernsey	4384	26-9-32	6-8-39	60	30	2,010	4·90	98·52	S F. Russell .	Koojan Ace's Advocate (2272)
Blacklands Daphne 6th ...	A.I.S.	9290	2-11-32	19-9-39	120	8	3,765	2·53	95·34	A. E. Grant . ..	Fussy's Monarch of Hill View (493)

Experiments in the Feeding of Phosphorus Supplements to Sheep in Western Australia.

by

E. J. UNDERWOOD, F. L. SHIER AND A. B. BECK.

Introduction.

Supplementing the diet of grazing stock with phosphorus in the form of phosphatic licks has been practised in different parts of the world for many years. It is natural that such a practice should have received considerable prominence in Australia where the soils are in general low in available phosphorus and where the climate of much of the country is characterised by long dry periods when the grazing is exceedingly poor. In Western Australia the use of phosphatic licks was of little consequence prior to 1928 when in the dry summer months the occurrence of botulism in sheep due to the consumption of rabbit bones and carcases carrying the toxin of *Clostridium botulinum* was first recognised. (Bennetts, 1933). A greatly increased use of phosphate supplements in the form of licks followed recommendations based on the classical South African work demonstrating the relation of this disease in cattle to phosphorus deficiency. Experience of farmers in Western Australia during the next few years with such licks, however, was, in general, disappointing and extensive experiments carried out in the summers of 1933-4 and 1934-5 completely failed to confirm the suggestion of phosphorus deficiency (Underwood & Shier 1935, 1936). A large consumption of a soluble phosphatic lick during two successive dry summers produced no increase in live weight of young or old sheep grazed on cereal stubbles and dry grazing typical of the areas involved and no decrease in the incidence of the pica impelling the sheep to consume infected carrion. In addition the levels of inorganic phosphorus in the blood of the sheep receiving no supplement remained at "normal" levels, though a fall in such levels is regarded as a very sensitive index of phosphorus deficiency. Further experiments (Underwood, Beck and Shier 1939) confirmed the absence of phosphorus deficiency as a primary factor in the welfare of the sheep and showed that the nutritional disabilities and the incidence of the pica were largely a reflection of the inadequate amounts of available protein and energy supplied by the dry summer grazing

During this time the idea of the existence of extensive phosphorus deficiency in grazing sheep in Australia was seriously challenged by the work of the Division of Animal Nutrition of the C.S. & I.R. in South Australia. Studies on the phosphorus requirement of the growing Merino were carried out (Martin and Pierce, 1934) and experiments with growing lambs depastured on phosphorus-deficient country at Dismal Swamp in South Australia failed to show any benefits on growth or wool yield from the use of phosphatic supplements. The consumption of these supplements, however, was quite low. (Marston & Lines, 1934). Furthermore, Marston (1935) has pointed out that successful results from the use of phosphorus supplements with cattle grazing on phosphorus low country do not necessarily mean that similar results will be obtained with sheep grazing under the same conditions. The lower skeletal proportions of sheep and the higher food consumption per unit live weight would enable sheep to fulfil their phosphorus requirements from herbage with a considerably lower concentration of P, than cattle.

The need for further field experimentation on this matter therefore became imperative and towards the end of 1935 the C.S. & I.R. decided to initiate experiments in the Eastern States with the object of obtaining a direct answer to the question as to the conditions under which the use of phosphatic licks for sheep might or might not be justified. In the same year the Department of Agriculture in Western Australia decided to conduct experiments in two places along closely similar lines to those laid down by the C.S. & I.R. and in co-operation with them. This was done so that the earlier work on the use of phosphatic licks, already mentioned as having been carried out in Western Australia, could be extended and at the same time a direct comparison of the results be made with those obtained in other parts of Australia. The present paper records the technique and results of these experiments.

Location of Experiments.

It was decided to carry out the experiments at the Merredin and Wongan Hills Research Stations which experience seasonal conditions typical of a large part of the agricultural areas of Western Australia, with the exception of the extreme south-west corner of the State. These conditions are characterised by a mild, moist winter and spring when virtually all the effective rainfall occurs and plant growth takes place and a hot, dry summer of about six months duration when there is usually little rainfall and no crop or pasture growth. The definite seasonal incidence of the rainfall is clearly shown in Table 1 where the mean monthy rainfall figures for Merredin and Wongan Hills are given.

TABLE 1.

MONTHLY RAINFALL FIGURES.

——	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Merredin	42	48	96	96	155	201	215	159	105	88	45	53	1,303
Wongan Hills	38	57	89	78	193	288	264	213	110	81	41	42	1,494

For six months of the year therefore sheep in these areas have to subsist on dry grazing consisting of cereal stubbles and poor annual pasture species which become progressively poorer in quantity and quality as the summer advances. The seasonal variation in the composition of such herbage and especially its extremely low nutritive value in the late summer and early autumn prior to the first effective rains has been shown by Underwood, Shier and Harvey (1937). The phosphorous content of samples of the dry grazing, selected to conform as far as possible to the material actually consumed by the sheep, was found by these workers to fall from about 0.12 per cent. P. on the dry matter in the early summer to as low as 0.07 per cent. P. at the end of the summer period. Supplementary feeding of the sheep with fodders, principally cereal hay and grain, grown in the previous year is widely but not universally practised.

The Merredin Research Station is situated about 160 miles east of Perth towards the eastern and drier end of the wheat belt. Its soils are principally brown clay-loams with calcareous clay subsoils similar to much of the forest soils of the eastern wheat belt. These soils must be considered of high fertility on Western Australian standards.* Excellent cereal crops can be grown on these soils with the use of superphosphate. The Wongan Hills Research Station is situated about 90 miles north-east of Perth on sandy soils typical of the better

* The majority of W.A. soils are, according to Teakle (1937-8) exceptionally low in phosphate of low availability.

class lateritic sand plain which occurs throughout the agricultural areas. The soil is acid in reaction, non-calcareous, and of exceedingly low initial fertility. Quite good cereal crops, however, can be grown in these soils with the use of adequate superphosphate, though in its absence practically no yield at all is obtained.

Experimental Procedure and Layout.

Merredin.

Early in January, 1936, 150 mated merino ewes were divided into two even groups by drafting, care being taken to ensure an equal age distribution in each group. These sheep had all had access to a phosphatic lick known as Dicalcic Lick* for the previous few weeks. One of the groups (A) was then given access to Dicalcic Lick and the other group (B) to common salt exposed in covered wooden troughs. Until 29/4/36 it was necessary to run these together as one flock and to separate for about 8 hours on three days of each week when they were given access to their appropriate supplements. Thereafter the two groups were run in separate paddocks and alternated weekly. The licks were continuously available and the consumption measured by weekly weighings of the troughs. All the ewes were weighed at approximately fortnightly intervals.

In the late summer the grazing became so poor that a small supplement of wheaten hay at the rate of ¾ lb. per head per day was fed to the ewes in both groups during May and June. Some measure of hand feeding is generally necessary in these areas during the late summer and autumn prior to the advent of green feed, particularly for pregnant and lactating ewes. In the present experiments is was thought necessary to keep such feeding to a minimum and by May a number of pregnant ewes and lambs had been lost. The very poor nutritive conditions were responsible for the loss of 30 lambs as well as a number of pregnant ewes. Lambing commenced on 6/4/40. Only 40 lambs survived from Group A and 45 lambs from Group B so a further 54 ewes were added to each group to give more effective numbers for carrying on the experiment in subsequent years. After allowing for deaths and culling in the original flocks this gave two new groups of 120 ewes in Group A and 117 ewes in Group B.

These two groups were mated in December, 1936, and given access to dicalcic lick and to salt during the 1936-7 summer and autumn as in the previous year. The two groups were grazed together and given access to the appropriate lick three times weekly until January 8th, when suitable separate paddocks became available. For a period of one week the phosphate was given to Group A in the form of neutral sodium phosphate drench at the rate of 2.3 gm. P three times weekly and the salt to Group B in a drench supplying the same amount of sodium as Group A. Owing to practical difficulties the drenching was discontinued with the ewes and the procedure of placing the licks in troughs adhered to. The drenching method was used throughout for the 1936 drop lambs and was also used later in the treatment of the 1937 drop lambs.

Lambing commenced in April, 1937, as in the previous year. Weighing of the ewes was discontinued during the lambing period as the continuous mustering and drafting, etc., was responsible for some of the losses in the previous year. The grazing conditions were not so poor in the late summer as in 1936, but a severe wind storm at the end of February blew away a large proportion of the dry grazing of the stubble paddocks, necessitating hand feeding of the

* The Dicalcic Lick contained common salt 38%, molasses 5%, phosphoric acid (P_2O_5) [illegible]% of which 90% was present as dicalcic phosphate.

ewes in both groups during May with about 1 lb. of wheaten hay per head per day, and small amounts during June. The lambs from each group were ear-tagged, weighed fortnightly and given phosphate or salt according to whether they were in Group A or B. The supplements were not given in the period approximately June-November in any year, since the grazing was at its best at this time and supplying relatively large amounts of phosphorus. The actual periods during which the feeding of lick and salt and the drenching was carried out is indicated on the graphs of the live-weights of the different groups.

In November, 1937, the weighings of the original groups of ewes (the mothers of the 1936 and 1937 drop lambs) was discontinued and the experiment continued until the end of 1939 with the young sheep only.

Wool yields (i.e., fleece weights) were obtained individually from the sheep at the ordinary shearing time in each year. The yields for the mature ewes are given for 1936 and 1937; for the 1936 drop lambs for 1937, 1938 and 1939, and for the 1937 drop lambs for 1938 and 1939.

Wongan Hills.

At Wongan Hills the layout and procedure was the same except that in both 1936 and 1937 the ewe groups were grazed in separate paddocks (which were alternated frequently) with their appropriate licks. In 1936 there were 73 ewes in each group which were increased to 150 in 1937. In 1936, for similar reasons as at Merredin, lamb and ewe losses were high. Thirty-two lambs were tailed from A Group and 27 from B group. Only small amounts of hay were fed during May and early June. In 1937, with better summer grazing, a ration of 1 lb. of cereal hay during late April and May and less handling, a better lambing resulted; 112 lambs were tailed from Group A and 109 from Group B.

The progeny, both 1936 and 1937 drop, were drenched as at Merredin. The periods of such drenching are indicated on the graphs of their live weight.

Lick Consumption.

In 1936 and 1937 the phosphatic lick, containing 18% P_2O_5 very largely as dicalcic phosphate, was made available to the ewes of Group A at both Merredin and Wongan Hills during the periods of poor grazing. Salt alone was made available to the ewes of Group B. The lick was found very palatable and consumed at Merredin at the rate of approximately 4 ozs. per head per week during this period, both in 1936 and 1937. This amount of lick supplied 1.4 gm. of P per day to the sheep. At Wongan Hills the average consumption during this period was 5 ozs. or 1.8 gm. P per sheep per day in 1936 and approximately 4 ozs. or 1.4 gm, P per sheep per day in 1937. The consumption of lick and salt was very regular throughout the period of dry grazing but fell quickly to negligible quantities with the advent of green feed. Lick feeding was discontinued each year when this fall occurred.

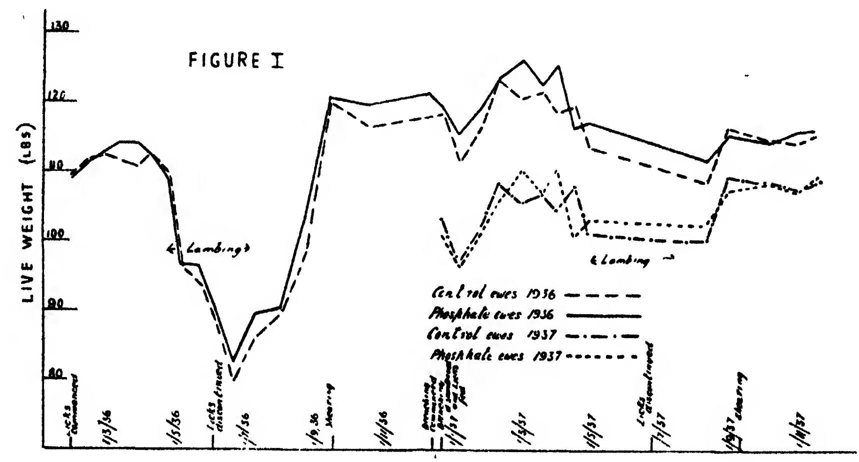
The salt was consumed by the ewes of Group B at the rate of 3 to 3.5 ozs. per head per week at Merredin and at 4 to 4.5 ozs. per head per week at Wongan Hills in both years.

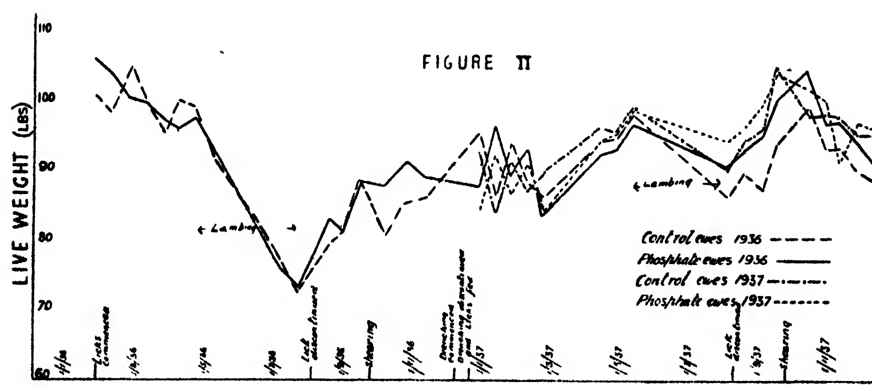
As stated earlier the lambs from the phosphate fed ewes were not given lick but were dosed three times weekly from January to June in each year with a sodium phosphate drench supplying 2.3 gm. P per dose. The control lambs were dosed with a solution of common salt supplying equivalent amounts of sodium.

Body Weights of the Ewes.

The mean fortnightly body weights of the Merredin ewes are presented graphically in Figure I, and of the Wongan Hills ewes in Figure II.

The graphs are to a large extent self-explanatory. It is quite obvious that the phosphate fed sheep have not maintained significantly higher live weights than those receiving salt only. The very large falls in weight during April-June, 1936, are accounted for by the combined effects of the losses due to lambing and





Graphs showing the mean fortnightly live weights of the experimental ewes at Merredin (Fig. I) and Wongan Hills (Fig. II).

the exceptionally poor grazing conditions at this time. It will be noted that the falls during the same period are not nearly so great in the 1937 season, either at Merredin or Wongan Hills, although, owing to no weighing being carried out during the 1937 lambing, the lowest level at the peak of lambing is not recorded. In this connection it should be mentioned that a comparison of the mean live weights of the two groups at these times as depicted in Figures I and II is not strictly accurate since it involves the assumption that either all the ewes in each group, or the same proportion in each group, have lambed. This is not so, but

the lambing percentages in Groups A and B, both in 1936 and 1937, at Merredin and at Wongan Hills, are not sufficiently different to appreciably affect the comparison. For simplicity, therefore, the groups are compared as a whole.

Lambing Results.

Details of the lambing results are presented in Tables 2, 3 and 4 and call for little comment. The proportion of lambs dropped to ewes mated is normal in the 1937 season at both Merredin and Wongan Hills. In the 1936 season at both places the losses at lambing time were very heavy for reasons mentioned previously and in consequence the lambing percentages, as expressed on the basis of the lambs tailed, is much lower than in 1937. In 1936, 16 lambs died at birth in each group at Merredin, whilst at Wongan Hills in all 29 were found dead in the paddocks, but no record was kept of the number from each group.

At both stations the 1936 drop ewe lambs were mated at the end of 1938, the results of which are shown in Table 4. Little importance can be attached to these results, however, owing to the small numbers of ewes involved.

At Wongan Hills in December, 1939, the 1936 drop ewe lambs were again mated, together with the 1937 drop ewes. From 64 phosphate ewes 48 lambs were tailed, or 75% and 44 lambs from 53 control ewes, or 83%.

TABLE 2.

LAMBING RESULTS—1936.

—	Merredin.		Wongan Hills.	
	Phosphate.	Control.	Phosphate.	Control.
No. of ewes mated	75	75	73	73
No. of lambs dropped	61	63	*	*
Percentage lambing	81	84	*	*
No. of rams tailed	22	22	12	13
No. of ewes tailed	23	27	20	14
Percentage of lambs tailed	60	65	44	37

*4 lambs killed by foxes and 25 found dead but the number from each group was not recorded.

TABLE 3.

LAMBING RESULTS—1937.

—	Merredin.		Wongan Hills.	
	Phosphate.	Control.	Phosphate.	Control.
No. of ewes mated	121	117	150	150
No. of lambs tailed	93	87	114	114
Percentage of lambs tailed	77	74	76	76
No. of wethers at weaning	40	46	52	57
No. of ewes at weaning	52	40	57	50

TABLE 4.

LAMBING RESULTS—1939.

—	Merredin.		Wongan Hills.	
	Phosphate.	Control.	Phosphate.	Control.
No. of ewes mated	19	21	16	11
No. of ewes died before lambing ...	2	...	...	...
No. of lambs born	13	17	15	9
Percentage lambing	68	81	94	82
No. of lambs tailed	11	15	14	9

It is apparent that the phosphate has had no effect on the lambing percentages. The small differences apparently in favour of the controls at Merredin in 1936 and of the phosphatic group at Merredin in 1937 and Wongan Hills in 1936 are not significant. The difference of 8% at Wongan Hills in favour of the control group at the 1940 lambing of the 1936 and 1937 ewe progeny is also not significant. The proportion of ewe to ram lambs born in each group is variable at the two centres and also in different years, and it is obvious that there is no difference between the groups in this respect. No effect of the phosphate feeding on the proportion of ewes or rams surviving to weaning is evident.

The birth body-weights of the 1936 lambs at Merredin only were obtained. The mean birth weights of both the ewe and ram lambs are almost identical both within and between treatments. Thus in the phosphate group the mean birth-weight of the ram lambs was 8.3 lbs. and of the ewe lambs 8.4 lbs. The corresponding figures for the controls was 8.1 lbs. and 8.2 lbs. respectively. It is apparent that the phosphate supplement consumed by mothers during the gestation period when the grazing was at its worst has produced no improvement in the development of the lamb in utero.

Growth of Lambs.

The growth of the 1936 lambs until the middle of 1939 is presented in graphical form in figure III for the Merredin lambs and in figure IV for the Wongan Hills lambs. The mean live-weights for the ewes and the wethers in each group are graphed separately in each case. The wethers are consistently heavier than the ewes throughout, particularly at Wongan Hills, both in the groups receiving the phosphate and those receiving salt only.

At Merredin it is apparent that up to July 1938 there is no difference between Groups A and B, either in the case of the ewes or the wethers, since the lines representing the mean weights touch and overlap at a number of points. For the first few months of 1938 the wethers of Group A (phosphate) appear to be slightly heavier than those of Group B but the difference is not significant and can be shown to be due to chance alone. In July 1938 the wethers were discarded and the subsequent growth of the ewes only is recorded. For the following twelve months the phosphate appears to have produced and maintained higher live-weights compared with the ewes receiving the salt supplement only. At no point, however, do the mean differences approach statistical significance such as could be attributed to the effects of the treatment, i.e. the feeding of phosphate. It should be emphasised that the groups are small at this stage (Group A, 19, Group B, 21) and the individual variation in live weight large.

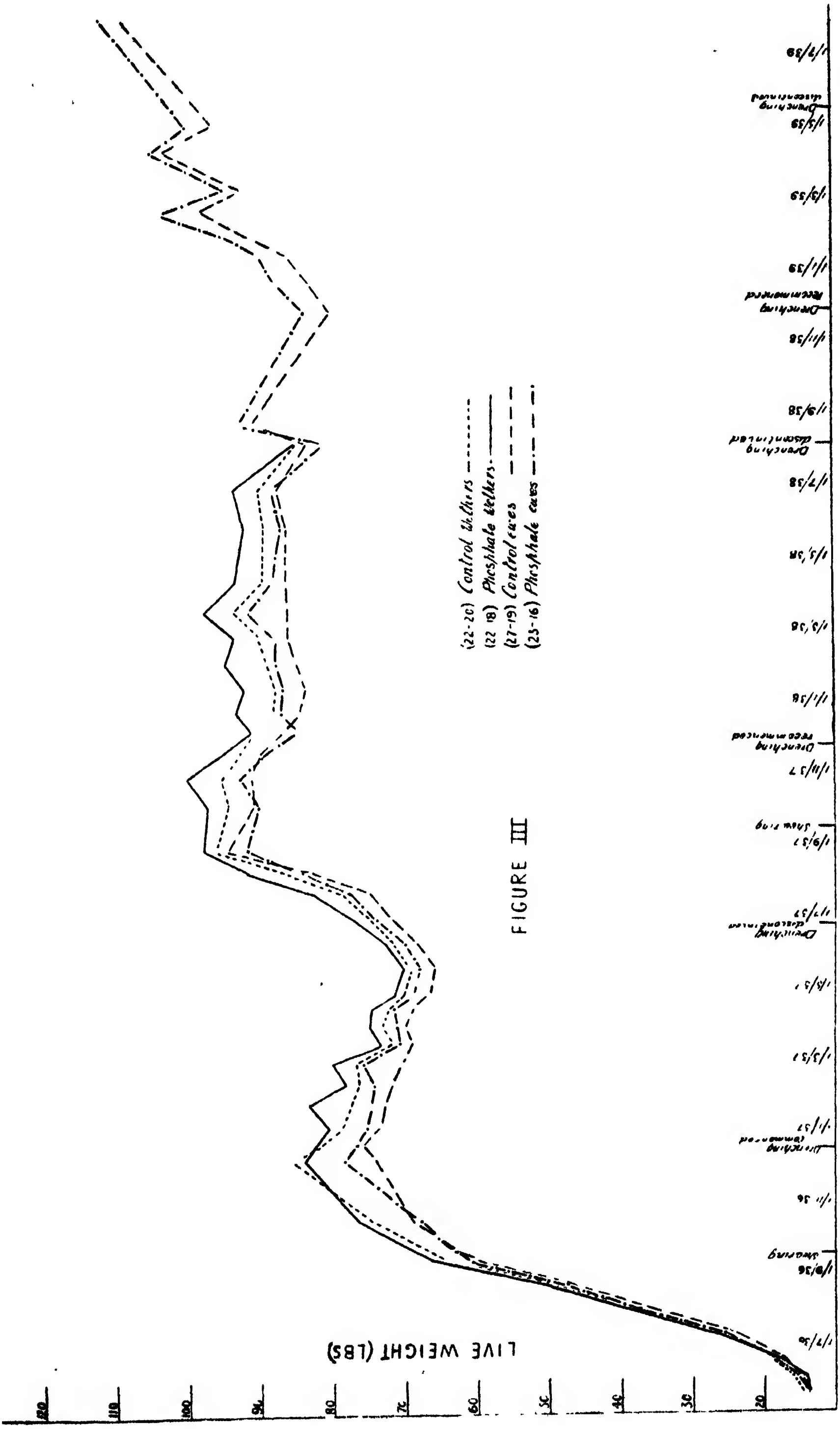


Figure III.
Graph showing the mean fortnightly live weights of the 1936 drop lambs at Merredin. The number of sheep in each group is shown in brackets.

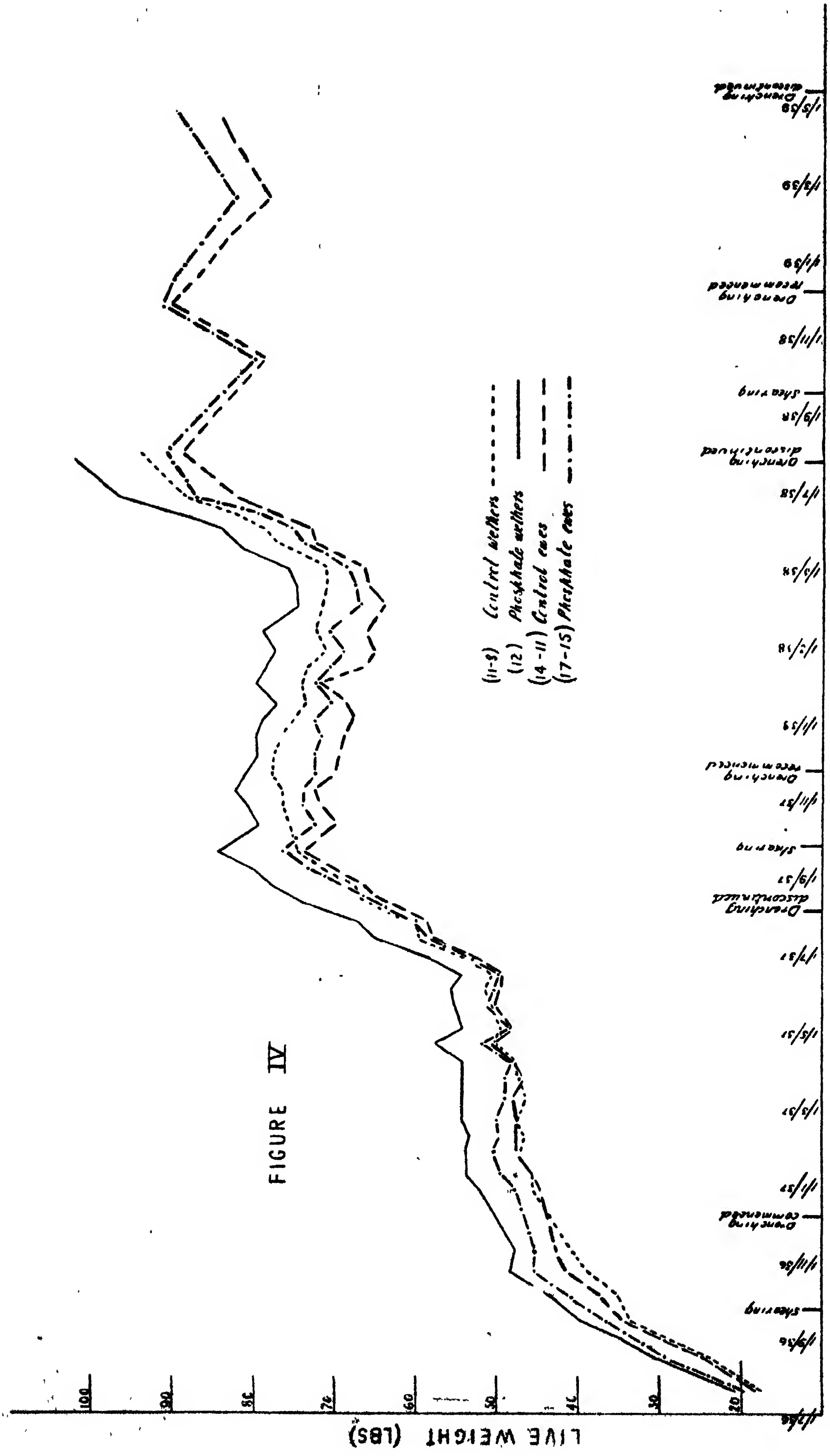
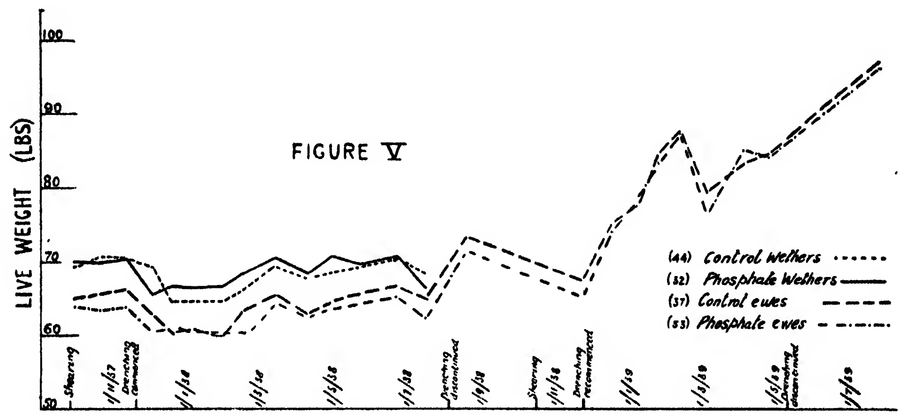
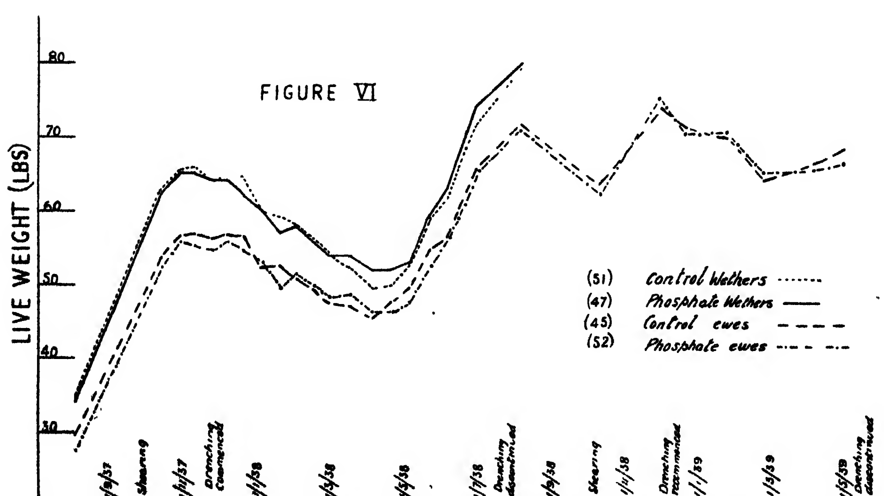


Figure IV.
Graph showing the mean fortnightly live weights of the 1936 drop lambs at Wongan Hills. The number of sheep in each group is shown in brackets.

At Wongan Hills (Figure IV) the position is very similar throughout, except that at several weighings between September 1937 and August 1938 the wethers of the phosphate fed group are significantly higher in mean live weight than the wethers of the salt group. This is very hard to understand and it is difficult to avoid the conclusion that some factor or factors other than the treatment is influencing these particular results. Neither during this period nor at any other time does the growth of the ewes show any significant response to the phosphate while the growth of neither ewes nor wethers of the 1937 drop lambs is affected by the treatment.

The growth of the 1937 drop lambs from September 1937 to August 1939 at Merredin is presented graphically in Figure V and from July 1937 to April 1939 at Wongan Hills in Figure VI. As before the mean live weights of the ewes and wethers in each group are graphed separately. Again the wethers in each group are consistently and significantly heavier than the ewes both at Merredin and Wongan Hills.





Graphs showing the mean fortnightly live weights of the 1937 drop lambs at Merredin (Fig. V) and Wongan Hills (Fig. VI). The number of sheep in each group is shown in brackets.

From the point of view of the effects of the phosphate supplements, neither Figure V nor Figure VI call for much comment. The mean live weight figures for both ewes and wethers are closely similar in Group A (phosphate) and Group B (salt) throughout the experiment. It should be noted that the graphs of the 1937 drop lambs represent the mean of twice the number of ewes or wethers (40-50 in each case) as is the case in the graphs of the previous years' lambs. This is of obvious importance where averages are being used as a basis for comparison and should be particularly borne in mind when considering the 1936 drop lambs at Wongan Hills shown in Figure IV. It is exceedingly doubtful if the apparent differences in the mean live weights of Groups A and B which show up at certain times in this graph would have been evident if larger groups had been used

A fact of some importance which emerges from Figures III, IV, and VI, is that the early growth of the lambs, i.e. from the first weighing shortly after birth up to weaning at 4-5 months of age, does not appear to have been affected by the treatment of the mother with respect to the phosphate supplement. This indicates that the milk yield of the ewes has not been influenced by the feeding of phosphatic lick during pregnancy in the preceding summer period, since the rate of growth of lambs up to 3-4 months of age is known to be controlled by the milk yield of the mothers.

Wool Production.

The yields of greasy wool were obtained at both Merredin and Wongan Hills from the ewes in 1936 and 1937 and from the young sheep (1936 and 1937 drop lambs) in 1937, 1938 and 1939. The yields from the 1936 or the 1937 drop lambs were not recorded in the year of their birth as they were only a few months old at shearing time. (September in each year). Machine shears were used and each fleece weighed individually with its belly, prior to the usual skirting. The total weight of locks for each group (prior to skirting) was obtained and the average figure added to the fleece and belly weight of each sheep.

No attempt to measure the yields of cleaned, scoured wool or of the spinning counts of the wool was made.

The Merredin wool results are presented in Tables 5, 6 and 7 and the Wongan Hills figures in Tables 8, 9, and 10. The results for ewes and wethers are presented separately, though no consistent differences in yield between them are apparent. In the 1937 shearings presented in Tables 6 and 9, however, the wethers have produced considerably and significantly more than the ewes both in the phosphate and the control groups. This difference appears to be associated with the rather heavier weights of the wethers at this time. It is noticeable that at the 1938 shearings there is no difference of this magnitude in favour of the wethers.

TABLE 5.

WOOL YIELDS—MERREDIN EWES.

Group.	1936.			1937.		
	No. of Sheep.	Mean Cut per Head.	Mean Live Weight before Shearing.	No. of Sheep.	Mean Cut per Head.	Mean Live Weight before Shearing.
		lbs.	lbs.		lbs.	lbs.
Group A (Phosphate)	73	10·2	121	114	11·5	112
Group B (Controls)	70	9·9	120	111	11·7	113

TABLE 6.

WOOL YIELDS—MERREDIN 1936 DROP LAMBS.

Group.	1937.			1938.			1939.	
	No. of Sheep.	Mean Cut per Head.	Live Weight before Shearing.	No. of Sheep.	Mean Cut per Head.	Live Weight before Shearing.	No. of Sheep.	Mean Cut per Head.
		lbs.	lbs.		lbs.	lbs		lbs.
Phosphate Ewes	19	12·1	91	19	13·3	92	17	13·2
Control Ewes .	22	12·0	91	21	13 0	90	19	13 3
Phosphate Wethers .	18	13·3	97	17	12·9			..
Control Wethers	20	13·3	94	21	12 8			

TABLE 7.

WOOL YIELDS—MERREDIN 1937 LAMBS.

Group.	1938.			1939.	
	No. of Sheep	Mean Cut per Head.	Mean Live Weight before Shearing	No. of Sheep.	Mean Cut per Head.
		lbs.	lbs		lbs.
Phosphate Ewes .	52	11·1	72	52	12·7
Control Ewes .	37	11·1	73	36	13·5

TABLE 8.

WOOL YIELDS—WONGAN HILLS EWES.

Group.	1936.			1937.		
	No. of Sheep.	Mean Cut per Head.	Mean Live Weight before Shearing.	No. of Sheep.	Mean Cut per Head.	Mean Live Weight before Shearing.
		lbs.	lbs.		lbs.	lbs.
Group A (Phosphate) ..	72	8·8	89	138	9·3	102
Group B (Controls) ...	69	8·8	89	139	9 2	100

TABLE 9.

WOOL YIELDS—WONGAN HILLS 1936 LAMBS.

Group.	No. of Sheep.	Mean Cut per Head.	Live Weight before Shearing.	No. of Sheep.	Mean Cut per Head.	Live Weight before Shearing	No. of Sheep.	Mean Cut per Head.
		lbs.	lbs.		lbs.	lbs.		lbs.
Phosphate Ewes	16	7·6	77	16	10·1	91	16	7·8
Control Ewes	11	7·4	73	12	10·4	89	11	8 6
Phosphate Wethers	12	8·3	84	12	11·0	103		.
Control Wethers	8	8·0	74	8	10·0	94		

TABLE 10.

WOOL YIELDS—WONGAN HILLS 1937 LAMBS.

Group.	1938.			1939.	
	No. of Sheep.	Mean Cut per Head.	Mean Live Weight before Shearing.	No. of Sheep.	Mean Cut per Head.
		lbs.	lbs.		lbs.
Phosphate Ewes	53	8·6	71	51	7·8
Control Ewes	47	9·0	72	44	8·0
Phosphate Wethers	45	9·6	80	....	...
Control Wethers	47	9·2	79	....	..

It is evident from Tables 5 and 8 that the mature ewes of the phosphate groups have not produced any more wool than the controls in either year or at either place. In general the results were similar for the young ewes and wethers, though the mean group values are more variable. Thus the 1936 control wethers at Wongan Hills have a mean yield of 1.0 lb. lower than the phosphate wethers at the 1938 shearing, whilst at the 1939 shearing the control ewes have a mean yield of 0.8 lb. heavier than the phosphate ewes. At Merredin the control and the phosphate fed ewes from the 1937 drop lambs showed no difference in mean yield at the 1938 shearing but at the 1939 shearing the controls yielded an average of 0.8 lb. more wool per head. Such fluctuations are a reflection of the small size of the groups and the considerable individual variation within the groups. Statistical treatment of the results shows that in no case can such mean group differences as do occur be considered significant.

Blood Phosphorus Levels.

The level of inorganic phosphorus in the blood of sheep has been shown by numerous workers to be a very sensitive index of phosphorus deficiency. Earlier studies carried out in this State in connection with the botulism investigations previously mentioned (Underwood and Shier 1935, 1936) had shown that no falls in these levels below "normal" values occurred in the experimental sheep, even in the late summer and autumn after several months on poor, dry grazing. It was considered advisable however, to extend these findings in the present experiments especially in view of the longer period, and the more severe nutritive conditions. Accordingly periodic determinations of the blood inorganic phosphorus levels were carried out on small groups (8-20 sheep) selected at random from the whole groups under treatment. As blood phosphorus levels may show large diurnal variations, the following precautions were adopted to ensure that all the figures were comparable; the bleeding was done during the same period of each day, A's and B's were bled alternatively, rumination was prevented while the sheep were in the yards, and the A group received no phosphate for at least 18-24 hours before testing. The blood samples were taken from the jugular vein and up to the end of 1936 the inorganic phosphorus content was estimated by the method of Malan and Van der Lingen (1931) thereafter the method of Fisk and Subbarow (1925) was used. In order to conform with other published results the values are calculated on the assumption that the trichloracetic acid precipitate occupies a negligible volume. Actually this involves an error of 9% since it has been shown by Thivolle and Laugier (1938) that the precipitate contains an appreciable amount of "bound" water.

The results are set out in Tables 11-16. Only group means at each sampling are given, together with standard errors and differences necessary for significance between date means.

BLOOD INORGANIC PHOSPHORUS LEVELS (mg. P. per 100 mls.)—MERREDIN.

TABLE 11.

MATURE EWES.

Date		20-2-36	26-3-36	8-5-36	2-7-36	8-1-37	18-3-37	30-7-37	27-8-37	11-11-37*	Treatment Mean.
Controls ..	Mean .	3 40	3·82	4·08†	3 98‡	4·19	4 11	2·41‡	2·39‡	4·23	3·55
Phosphate Group	Treatment	Phosphate Fed.			Grazing only	Phosphate Fed		Grazing only			....
	Mean .	3·37	4·10	4·42†	4·06‡	4·89	4·11	2·49‡	2·32‡	4·38	3·72
Date Mean		3·39	3·96	4·25†	4·02‡	4·54	4·11	2·45‡	2·36‡	4·30	3·64

* The results of 11–11–37 not included in statistical treatment or in " Treatment Mean " as only a small group tested on this date. † Lambing period. ‡ Lactation period.

Standard Error for Mean of Dates = ± 0·1637 Difference for Significance (P = 0·05) = ± 0·322.

TABLE 12.

1936 DROP LAMBS

Date . .		30-7-37	11-11-37	13-1-38	24-3-38	16-6-38	3-11-38	29-3-39	18-4-39*
Controls .	Mean	4·80	4·47	4·20	4 60	4·13	4·69	3·11	3·26
Phosphate Group	Treatment	Phosphate Fed	Grazing only	Phosphate Fed			Grazing only	Phosphate Fed	
	Mean	4·64	4·33	4·67	4·63	4·53	4·44	2·71	3·47
Date Mean .		4·72	4·40	4 43	4·62	4·33	4 56	2·91	3 36

Ewes and wethers 30–7–37 to 16–6–38. No significant difference between treatments or dates.

* During lambing. Ewes only 3–11–38 to 18–4–39. Results not analysed statistically as only a small group tested.

TABLE 13.

1937 DROP LAMBS.

Date		13-1-38	24-3-38	16-6-38	Treatment Mean.	3-11-38	29-3-39	18-4-39	Treatment Mean.
Controls	Mean	4·30	5·20	4·66	4·72	5·14	3·42	4 30	4·28
Phosphate Group	Treatment ..	Phosphate Fed			.	Grazing only	Phosphate Fed		
	Mean ...	4·85	4·96	5·53	5·11	4·82	3·32	4 15	4·10
Date Mean		4·57	5·08	5·09	4·92	4·98	3·37	4·23	4·19

Ewes and wethers 13–1–38 to 16–6–38. Standard Error for Mean Dates = ± 0·1894. Difference for Significance (P = 0·05) = ± 0·38.

Ewes only 3–11–38 to 18–4–39. Standard Error for Mean of Dates = ± 0·1509. Difference for Significance (P = 0·05) = ± 0·30.

BLOOD INORGANIC PHOSPHORUS LEVELS (mg. P. per 100 mls.)—WONGAN HILLS.

TABLE 14.

MATURE EWES.

Date		13-2-36	19-3-36	30-4-36	9-7-36	14-1-37	16-4-37	23-7-37	9-11-37*	Treatment Mean.
Controls	Mean	3·89	4·62	3·61†	4·01‡	4·42	4·04	3·10‡	3·03‡	3·96
Phosphate Group	Treatment	Phosphate Fed.							Grazing only	...
	Mean	5·19§	4·33	3·65†	3·64‡	4·14	3·72	3·05‡	3·04‡	3·96
Date Mean		4·54	4·48	3·63†	3·82‡	4·28	3·88	3·07‡	3·04‡	3·96

* The results of 9–11–37 not included in statistical treatment or in "Treatment Mean," as only a small group of sheep tested on this date.

† Lambing period.

‡ Lactation period—majority of sheep dry on 9–11–37.

§ These sheep bled in afternoon; had access to phosphate lick in morning.

Standard Error for Mean of Dates = $\pm$ 0·2035. Difference for Significance (P = 0·05) = $\pm$ 0·401.

TABLE 15.

1936 DROP LAMBS.

Date		15-4-37	22-7-37	9-11-37	20-1-38	22-3-38	5-7-38*	9-11-38	28-3-39	Treatment Mean.
Controls	Mean	5·05	4·97	4·26	4·16	5·19	5·25	5·19	4·25	4·80
Phosphate Group	Treatment	Phosphate Fed		Grazing only	Phosphate Fed.			Grazing only	Phosphate Fed	..
	Mean	4·96	5·62	4·21	4·61	4·86	5·00	4·81	4·35	4·79
Date Mean		5·06	5·30	4·24	4·39	5·02	5 12	5·00	4·30	4 80

* Ewes and wethers tested up to and including 5–7–38; ewes only after that date. Results treated statistically as one group.

Standard Error for Mean of Dates = $\pm$ 0·223. Difference for Significance (P = 0·05) = $\pm$ 0·442.

TABLE 16.

1937 DROP LAMBS.

Date		20–1–38	22–3–38	5–7–38*	9–11–38	28–3–39	Treatment Mean.
Controls	Mean	4·12	5·06	5·63	5·13	4·23	4·83
Phosphate Group	Treatment	Phosphate Fed			Grazing only	Phosphate Fed	...
	Mean	4·26	4·27	5·59	5·36	5·00	4·90
Date Mean		4·19	4·66	5·61	5·24	4·61	4·86

* Ewes and wethers tested up to and including 5–7–38; ewes only after that date. Results treated statistically as one group.

Standard Error for Mean of Dates = $\pm$ 0·195. Difference for Significance (P = 0·05) = $\pm$ 0·39.

It will be seen that there is no significant difference between controls and the sheep receiving phosphate; it is true that on certain dates the phosphate groups show significantly higher figures than the controls, but this is apparently quite fortuitous as at other times the controls show significantly higher figures than the phosphate group. The values obtained for the control sheep (except during the lambing and lactating period) all fall within the values of "normal" sheep and do not fall to levels which would indicate a phosphorus deficiency.

The only differences which are significant are those between dates, and here the main causes seem to be those associated with lambing and lactation. As has been pointed out elsewhere (Underwood and Shier, 1936) these two factors seem to produce rather uncertain results. For example, at Merredin in 1936 the effect of lambing and lactation seemed to have no effect on the blood phosphorus levels of the ewes; in 1937 lactation produced a large fall which persisted until at least the end of August; in 1938 some unpublished experiments on another group of ewes showed some low levels which, however, returned to normal before the middle of June. The reason for these variable falls is at present obscure and is deserving of further investigation. It should be noted, however, that they occur during the period of the year when the grazing is supplying most phosphorus. Moreover, the controls and the phosphate ewes appear to reduce their blood inorganic phosphorus levels to about the same extent.

Discussion.

Most of the significant points have been discussed to a certain extent in the sections dealing with the results of particular aspects of the experiments. These aspects dealt with the effects of a readily available phosphorus supplement on the body-weights of mature ewes, on the growth of lambs from these ewes, on the birth weights of lambs and the numbers of lambs dropped, on the wool production of both the mature and growing sheep and on the blood inorganic phosphorus levels. In all these phases of the work the results are consistently and overwhelmingly against any evidence of phosphorus deficiency or of any benefit, economic or otherwise, accruing from the use of phosphatic licks. It is true that there is an apparent improvement in the growth of the wethers of the 1936 drop lambs for a time during the 1937-38 season at Wongan Hills but, as pointed out earlier, no such effect was apparent at this time with the ewes born at the same time and carried under identical conditions, or with the 1937 drop lambs (ewes or wethers) either during this same period or in subsequent years. In the case of the 1937 drop lambs it would be expected that any benefit from the use of a phosphate supplement would show up more readily than in the case of the 1936 lambs, since the mothers of half of such lambs (1937 drop) had, in the case of the "B" group, had two successive summers without any extra phosphorus, one of them exceptionally severe, whereas in the previous year the mothers of the 1936 drop lambs had had only one summer period of poor, dry grazing.

The conditions and the length of time under which the experiments were carried out preclude any possibility that the test was not severe enough. The soil and grazing conditions at the two places studied were, as pointed out before, typical of large sections of the agricultural areas where sheep are run. At Wongan Hills the soils are of exceptionally low fertility, particularly in regard to phosphorus; at Merredin they are very much better but must still be considered poor in this factor. The 1935-36 summer and grazing conditions were very severe indeed at both Merredin and Wongan Hills. The 1936-7 season was only fair and the 1937-8 season again very poor. It is evident therefore that the conditions of the experiment were considerably poorer, rather than better, than normal for the areas concerned. It would be expected therefore that if any

benefit from the use of phosphatic licks were ever going to show up it would do so under these conditions. Furthermore the experimental sheep were carried through the dry summer period with a bare minimum of hand feeding. The only conserved fodder fed was ¾ to 1 lb. of cereal hay (containing approximately 0.15 per cent. P.) per head per day to the lambing ewes for 1-2 months in the autumn. The hand feeding was definitely below the levels consistent with good sheep husbandry whilst during the 1935-36 summer heavy losses of both ewes and lambs resulted from the very poor nutritive conditions.

A further point which requires emphasis is that the effects of the phosphate supplement were measured over four successive seasons, three of these with the same sheep born of ewes which had themselves been under experiment for a year previously. This distinguishes the present experiments from the previous work in Western Australia in connection with the botulism investigations in which different groups of sheep were used in successive years. It supports the earlier results showing that there is no sign of phosphorous deficiency in the long, dry summer period, either with young or old sheep and shows further that there is no evidence of a cumulative deficiency operating with young sheep over three years (two of them exceedingly poor) or with breeding ewes, either on the fertility or subsequent growth of wool yield of their lambs.

It is hardly necessary to point out that these results apply only with certainty to the drier agricultural areas of Western Australia. The results are such, however, as to make it difficult to conceive of any extensive areas either in this State or elsewhere in Australia where the use of phosphatic licks for sheep would be justified. Support for this statement comes not only from the very conclusive nature of the present experiments and those carried out earlier in this State, but from field and laboratory studies in South Australia and from the recent experiments conducted in Queensland. These experiments were carried out over a two year period under pastoral conditions representative of an extensive tract of country in the drier areas of western and north western Queensland. No benefit was obtained from the use of a phosphatic lick on the growth and development of lambs, on the lambing percentage or birth weights or on the wool production. It is evident that a considerable amount of money and effort has been and is being wasted by sheep owners in Australia in providing various forms of phosphate supplements to their sheep.

The above results raise the question of what are actually the P requirements of sheep. This matter cannot be appropriately discussed in this paper but the experiments of Martin and Pierce (1934) and du Toit, Malan and Groenewald, (1932) suggest that, for the merino at least, about 1 gm. P. per day must be considered to be very close to the minimum requirement, where the other dietary essentials are adequately supplied. Analyses of samples of herbage typical of the grazing in the drier agricultural areas of Western Australia and selected to conform as far as possible to the material actually consumed by the sheep (Underwood, Shier and Harvey, 1937) indicate an intake of about 1.0 gm. P per day in December and January, falling in normal years to about 0.5 gm. in March and April. These figures might be interpreted as indicating a short period of phosphorus deficiency but it is exceedingly difficult to know just what the grazing sheep actually consume and it is possible that they may obtain by a high degree of selection a somewhat higher P intake. Moreover the period of low P intake invariably coincides with a low intake of protein and frequently with a low intake of total available energy. Whether such deficiencies have the effect of lowering the sheep's P requirements is not at present known though it is perhaps significant that an appreciable lowering of the basal metabolism under such dietary con-

ditions has already been established (Lines and Pierce, 1931). In any case it is perfectly obvious from the present experiments that under Western Australian conditions at least the sheep can die of starvation before any sign of P deficiency becomes evident.

Finally, a word of warning should be given against thinking that the above results apply also to cattle. As Marston has already pointed out, the phosphorus requirements of cattle in terms of the concentration of phosphorus in the grazing are of the order of twice that of sheep. In W.A. evidence of phosphorus deficiency in the bones of cattle has been observed on a number of occasions by veterinary officers while low blood phosphorus values highly suggestive of phosphorus deficiency have been found not infrequently in the drier agricultural areas by one of us (Underwood, 1936).

Summary and Conclusions.

1. Experiments in the feeding of soluble phosphate supplements to merino sheep on two farms typical of much of the drier agricultural areas of Western Australia, carried out over four successive seasons, two of which were exceptionally poor, are described.

2. Although one of these farms was situated on soils of exceedingly low phosphorus status, no effect of such supplements could be demonstrated at either place on the body weights of mature ewes, the growth of lambs from these ewes, the birth weights of the lambs, the numbers of lambs born, the wool production of either the mature or the growing sheep or on the blood inorganic phosphorus levels.

3. It is concluded that no benefit, economic or otherwise, is brought about in the agricultural areas of Western Australia by supplementing the diet of grazing sheep with phosphatic licks and that the use of such licks by sheep owners is both unnecessary and wasteful.

Acknowledgment.

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Pedigree Seed.

CEREAL VARIETIES AVAILABLE FOR DISTRIBUTION.

I. THOMAS, Superintendent of Wheat Farming.

With all phases of agriculture it is important that the breeding stock, whether for animals or plants should be of the highest standard. Plant breeding, even more than animal breeding, is highly specialised and complex, and such work is confined to relatively few centres. From the labours of these few workers, farmers all over the world are enabled to maintain the standard of their seed stocks at a high level, and with the least amount of trouble and expense to themselves

Though many do not avail themselves of this service, those who do so soon realise the benefits to be gained thereby.

In this State the raising of pedigree seed is one of the main activities of the Research Stations, the principal breeding centres being at Merredin and Wongan Hills. Such wheats as Nabawa, Bencubbin and Noongaar produced by the Department are notable instances of this work.

When making available supplies of pedigree seed it is not suggested that a farmer obtain all his supplies of seed in this way, nor would it actually be possible for him to do so. It is recommended, however, that each year farmers should obtain a few bags of the variety or varieties they normally grow, sow this in a "Stud" plot or plots and then use the grain obtained for their seed requirements the following year.

It must also be realised that the supply of any one variety or varieties is not unlimited, and that as it is the aim of the Department to distribute the seed as widely as possible, it is usually found necessary to limit the number of bags of each variety per applicant so that this may be achieved.

The following may be of assistance to farmers in determining the quantity of seed required each year to maintain their Stud plots—each bag of pedigree wheat will sow four acres at 45 lbs. per acre and if the yield from that plot were 15 bushels per acre, the yield total being 60 bushels, which after grading will provide sufficient seed to sow 70 to 75 acres the following year at 45 lbs. per acre.

As a result of present seasonal conditions the quantity of pedigree seed produced will be considerably reduced but it is anticipated that this year limited quantities of the following varieties will be available for distribution.

WHEAT.

Baroota Wonder.—A late maturing variety, resistant to flagsmut, but is liable to rust. This variety is recommended for hay in the better rainfall districts.

Bencubbin.—A midseason maturing variety resistant to flagsmut, but is very liable to rust and is not recommended for those districts where rust is feared.

Bungulla.—A selection from Bencubbin, early maturing, drought resistant variety, resistant to flagsmut, susceptible to rust, but tends to be rust escaping on account of its early maturity.

Comeback.—An early-midseason maturing variety of premium milling quality. It is resistant to flagsmut and rust escaping.

Fedweb.—Late mid-season variety bred by Dr. W. L. Waterhouse of Sydney University. Short strawed, resistant to flagsmut and stem rust. Suitable for early planting in rust liable districts.

Ford.—A midseason maturing variety, resistant to flagsmut and rust.

Geeralying.—A very early maturing variety, resistant to flagsmut and rust escaping. It is liable to shed.

Gluyas Early.—An early maturing variety, resistant to rust but liable to flagsmut.

Merredin.—An early maturing variety, susceptible to flagsmut, but rust escaping.

Nabawa.—A midseason maturing variety, resistant to flagsmut and rust. Recommended for those areas where rust is feared.

Noongaar.—A very early maturing variety which is drought resistant, being most suitable for areas having a short growing period and for very late planting in those districts having a better rainfall; resistant to flagsmut and rust escaping.

Pusa IV.—Early maturing variety of high quality grain, moderately resistant to flagsmut, rust escaping on account of early maturity.

Sutton.—A late maturing variety, resistant to flagsmut and moderately resistant to rust. This variety is not recommended for areas of low rainfall.

Totadgin.—An early maturing variety; resistant to flagsmut.

Yandilla King.—Late maturing variety, moderately resistant to flagsmut and liable to rust. Not recommended for areas of low rainfall.

OATS.

Algerian.—A late maturing variety. Owing to slow early growth it is not recommended for early green feed.

Burts Early.—An early maturing variety which is especially suitable for hay, silage and early green feed.

Guyra.—A midseason maturing variety mostly favoured for its grain which is large and plump.

Mulga.—An early maturing variety suitable for hay, grain, silage and early green feed; superior to Burt's Early for grain.

Wongan.—A very early maturing variety which was produced at the Wongan Hills Research Station from a cross between Mulga and Burt's Early. It has short, strong straw and is suitable for early green feed and grain in the drier areas or for late planting in the wetter districts.

BARLEY.

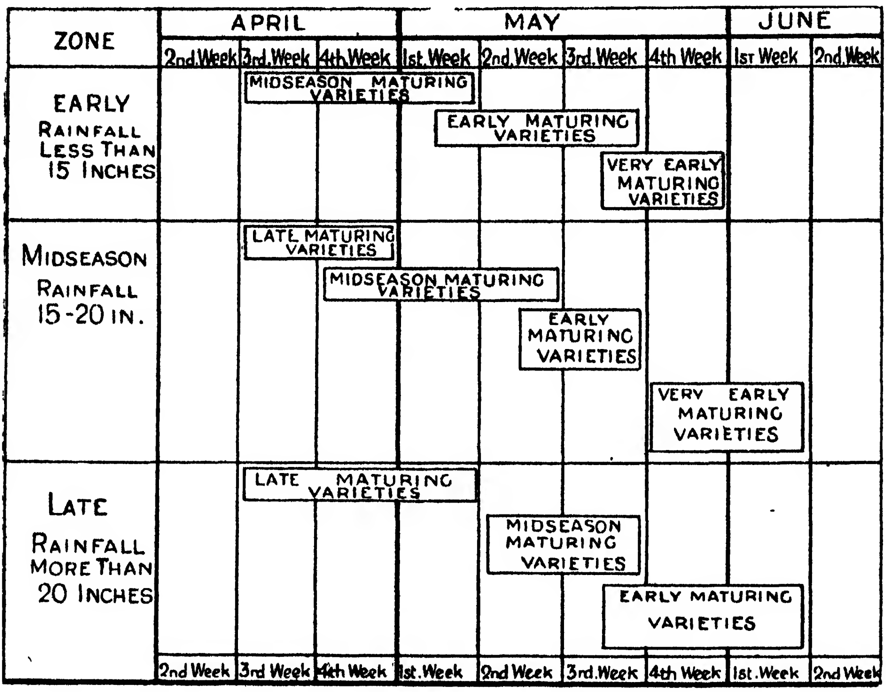
Atlas.—A six-rowed barley which has been introduced from California; it is also known in this State as Californian Six-Row Barley. In England it is used for malting purposes, but it is not employed for this purpose by local brewers whose technique is based on the use of two-row barleys such as Pryor.

It is recommended for green feed purposes, being superior to the other barleys and also the wheat, oat and rye varieties under general cultivation. It is also the most suitable six-rowed variety for export.

Pryor.—An early maturing two-rowed malting type grown mainly for local maltsters but is also satisfactory for green feed purposes.

Applications for pedigree seed should be made *direct* to the Department of Agriculture, Perth, and applicants are advised to make early application for their requirements, setting out clearly their name and postal address, together with the siding to which the seed is to be railed.

SEEDING CALENDAR WITH RECOMMENDED VARIETIES FOR THE WESTERN AUSTRALIAN WHEAT BELT.



RECOMMENDED VARIETIES.

Late Maturing.	Midseason Maturing.	Early Maturing.	Very Early Maturing.
Wheat—			
Sutton, Yandilla King, Baroota Wonder (for Hay) Fedweb	Bencubbin, Ford, Nabawa,	Gluyas Early, Merredin, Totadgin, Bungulla	Geeralying, Noongaar.
		Premium Varieties—Carrabin, Comeback, Pusa IV.	
Oats—			
Algerian	Guyra	Burt's Early, Mulga	Wongan.
Barley—			
		Atlas, Pryor	

Agricultural Problems.

Agriculturists, pastoralists and primary producers generally, who may be having difficulties of any kind in connection with their production activities, are invited to communicate with the Agricultural Adviser or Veterinary Officer of their district of the Department of Agriculture, when information and advice will be supplied free of charge.

Where identification of plant or stock diseases or insect pests is required, full details of symptoms should be forwarded and also samples of the diseased plant, animal tissue or insect where practicable. Plant tissue intended for examination by the Plant Pathologist should be wrapped in paper and not forwarded in airtight containers, and plant specimens for the Botanist should be pressed between newspaper and dried before despatch. With regard to animal tissue for microscopic examination, this should be forwarded in a solution of 10 per cent. formalin, or if of considerable bulk in a sealed kerosene tin containing a few ounces of formalin as a preservative. Living insects should be sent in suitable containers and dead specimens in methylated spirits.

The addresses and names of Advisers are as follows:—

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Bridgetown	A. M. Tindale (Dairying), A. Flintoff (Fruit).
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Notes on Control of Weevils in Wheat.

By C. F. H. Jenkins, Government Entomologist

INTRODUCTION.

A considerable amount of experimental work has been carried out recently by workers all over the world in an attempt to combat the weevil problem in stored wheat.

The ensuing experiments have been conducted locally and although the results cannot be regarded as final, sufficient information has been gathered to warrant its publication so that farmers and others may avail themselves of the conclusions reached and possibly be saved the time and expense of trying treatments already found ineffective.

In a recent article in this Journal, I outlined the habits and life-histories of our major grain pests and so do not propose to deal with those matters any further. I must stress again however the necessity for scrupulous sanitation in all matters connected with the storing of grain. The dust and liquid treatments which are about to be detailed must be regarded only as complementary measures to the first great essential—that of thoroughly cleaning out all containers and destroying infested refuse.

The experiments may be dealt with under two main headings—*Liquid Insecticides* and *Dusts*.

LIQUID INSECTICIDES.

The liquid insecticides can be used either for spraying out sheds, bins, trucks, etc., or for dipping bags, liners, etc. When spraying, it should be realised that the more powerful the pump is the better will be the results obtained; also, it is essential to spray thoroughly all portions of the truck or bin receiving attention as the sprays in question are what are known as contact insecticides and must hit the insects to prove effective.

A large number of liquids have been tested primarily with a purpose of finding a suitable dip for bags and liners, but any which are suitable as dips will also prove useful sprays.

The method of testing was to confine from 30-50 weevils (*Calandra oryzae*) in a piece of wheat sack and submerge them in the liquid for a specified time. The bundles were then allowed to drain for 24 hours when the weevil's were removed into a tube and the mortality noted. The mortality figures were again checked later to ensure that no recoveries had taken place.

In addition to various insecticidal and other solutions, dipping in pure water was tried as a control and also to test the limits of endurance of the insect.

The results of this experiment are as follow:—

Water.

Time Dipped.	Dead. (Per Cent.)
10 minutes	2%
7 days	10%
12 days	34%
16 days	100%

White Spraying Oil.

Although primarily prepared for use against insect pests of fruit trees, this oil has been shown to be very effective against weevils. A long series of experiments was conducted and the strength was varied from 1 part of oil to 30 parts of water to 1-200. The higher concentrations, as might be expected, gave the best results, but solutions of 1-60 proved most satisfactory, and even at 1-100 a high mortality was usually obtained. The time of dipping was varied from 10 minutes to one hour but the results did not show any marked increase in efficiency over 15 minutes, so that providing bags, etc., are not packed tightly so as to impede penetration, this time may be taken as a minimum.

Kerosene Emulsion.

This home made mixture proved most encouraging and if carefully prepared is an inexpensive and efficient insecticide. The emulsion was mixed at strengths varying from one part of emulsion to 15 parts of water to 1-30 and a mixture of 1-20 was found to be very effective. The time of dipping was again varied and 15 minutes was found to be satisfactory.

Red Oil.

This, like white oil, was primarily prepared as an insecticide for fruit trees but for use during the dormant period. Parallel experiments were run with Red and White oil at strengths varying from 1-100 to 1-200, but although the Red Oil had quite a considerable insecticidal value, it was so inferior to White Oil that it is not recommended if the latter is available.

Pale Spray.

This is another dormant fruit tree spray. It, like Red Oil, was inferior to White Oil, although moderately effective.

Home-made Creosote Emulsion.

This emulsion was tested at 1-50 for 15 minutes and one hour and very variable results were obtained. Some good kills were registered but these were off-set by some unaccountably low death rates.

Proprietary Creosote Emulsion.

This emulsion was tried at 1-50 and 1-75 for 15 minutes and one hour, but as with the home-made emulsion, the results did not show a consistently high mortality.

Condy's Crystals.

A ¼ per cent. solution was tried for 10 minutes, but as no deaths resulted the experiment was not continued further.

Formalin.

Commercial Formalin was tried at 1 per cent. for 10 minutes with only a 2 per cent. mortality and still further proof of its inefficiency followed a 100 per cent. recovery from dipping for one hour in a 3 per cent. solution.

Black Leaf 40.

Black Leaf 40 at 2 teaspoonsful plus one ounce of soap to the gallon of water gave only a 2 per cent. mortality and so was not tested further.

Copper Sulphate (Blue-Stone).

A 6 per cent. solution of Blue-Stone was tested for half an hour and one hour but the highest mortality obtained was only 14 per cent.

Hot Water Treatment.

Weevils are killed comparatively easily by heat and where containers or bags can be treated with boiling or nearly boiling water, weevils will be successfully killed. It was found that dipping for 15 minutes in water at 140° F. was sufficient to kill weevils but for practical purposes when large numbers of bags are being dipped, the water should be maintained as near boiling as possible.

Sheep Dip.

Immersion in a proprietary arsenical sheep dip at the strength prescribed for dipping sheep was tried for periods of ten minutes and one hour, 100 per cent. recovery occurred in both instances.

A word of warning may not be out of place to those who may have tried various dips with apparently satisfactory results. Frequently after being removed from a dip, weevils appear quite dead and the unwary experimenter is liable to be misled. The only sure test is to keep the apparently dead insects under observation for 24 or 48 hours. The percentage of recoveries which take place during this period is often astounding.

It will be readily apparent that there are a number of considerations which govern and restrict the choice of insecticides. Firstly, they should be effective in destroying the insects. Secondly, they must not be too expensive. Thirdly, they must not taint or adversely affet the grain. Fourthly, they should not increase the fire risk.

Items 2 and 4 are serious draw-backs to the use of Kerosene-pyrethrum sprays which are undoubtedly effective weevil killers, and item 3 rules out arsenical ones even if effective.

None of the mixtures used gave consistent kills of 100 per cent. but Kerosene Emulsion and White Oil were the only ingredients to ever achieve this percentage,

and as the results obtained with both were usually high, they are to be recommended. The other oil sprays and Creosote Emulsions, although giving inferior results to the above-mentioned dips, have certain properties as weevil killers. The remaining mixtures may be regarded as quite ineffective.

Preparing Kerosene Emulsion.

A little care is necessary in preparing this emulsion to prevent the kerosene rapidly separating out and floating on the water, but quite a satisfactory mixture can be made if the details are followed with reasonable care.

First, dissolve ½ lb. of soap in one gallon of boiling water. Remove from fire but while still hot pour slowly into the soap solution two gallons of kerosene. The mixture should be violently churned and stirred while the kerosene is being added to get a thorough mixture. A milky emulsion will result which can be kept for long periods if properly prepared. This mixture may then be used as prescribed at the rate of one part of emulsion to 20 parts of water. Care should again be taken to thoroughly agitate the mixture while it is being diluted. Although as stated the stock emulsion will keep for future use, there will be less chance of the kerosene separating out if it is used when mixed.

Creosote Emulsion.

The same particulars apply to the preparation of this mixture as to the kerosene emulsion, creosote being substituted for kerosene. The whole secret of getting a good emulsion is to thoroughly agitate the ingredients when they are being mixed. If hot water can be used throughout so much the better

DUSTS.

A number of so-called inert dusts have been shown to possess remarkable insecticide properties. One of the first to gain recognition was a proprietary silica dust known as "Naaki Dust," which has been widely tested in Germany and Russia. There seems to be some doubt as to how death is actually caused; some contend it is by the mechanical action of the dust entering the joints, etc., of the insects, while strong support is given to the theory that the dusts kill by their drying or desiccating action.

A wide variety of local dusts have been tested and all excepting two were ground so as to pass through a 200-mesh sieve. The diatomaceous earth was ground with a mortar and pestle; the iron pyrites residue was used as obtained.

The method of testing the dusts was to mix them at varying rates with clean wheat and add 50 weevils. Counts were taken at fixed intervals and the mortality noted.

The materials tested included ground quartz, diatomaceous earth, clays (several types), magnesite (several types), rock phosphate, borax, residue from roasted pyrites and salt.

Ground Quartz.

This dust was microscopically examined and 70-80 per cent. of the particles were 10 microns or under, the remainder going up to 50 μ. The most effective kills were obtained with a 1 per cent. concentration, and although the results varied considerably, some satisfactory results appeared.

Diatomaceous Earth.

This material was calcined and ground with a mortar and pestle. Microscopically it showed that 90 per cent. of the particles were below 10 μ with some of the longer spicules and diatoms reaching a length of from 30-50 μ. The rate was varied from 1 per cent. to 1/16th per cent. by weight and over the whole series of experiments very good results were shown, the percentage kill varying from 90-100 per cent. in seven days.

Clays.

Three clays of the bentonite type, collected from Bardoc, Watheroo and Collie, were tested at 1 per cent., but the results were not sufficiently encouraging to warrant further investigation.

Magnesite.

A hard and soft type of magnesite from Coolgardie were tested at 1 per cent. against a sample kindly supplied by the Council for Scientific and Industrial Research. Of the local dusts, the soft type was the more effective but was considerably inferior to the third sample against which it was being tested.

Calcined Magnesite.

When freshly calcined this material was most effective, giving kills of 100 per cent. in seven days, but after being kept for some time it recombined with moisture, became lumpy and less effective.

Rock Phosphate.

This dust gave quite good results.

Residue from Roasted Pyrites.

Variable results were obtained in the main comparable with those obtained by the soft magnesite.

Sodium Chloride.

Salt dried and ground was tested at 1 per cent., but proved quite ineffective.

Borax.

Although possessed of some lethal properties, it was inferior to several other dusts and much more expensive.

From the foregoing it will be seen that by far the most effective dust tried was the calcined diatomaceous earth. This was followed by the ground quartz. It is desired however for health reasons to find a suitable non-siliceous dust which will give effective control to weevils, and consequently experiments are still being carried on with magnesite and other likely materials.

To give the best results, a dust should be mixed with the wheat before it becomes infested, as when the grain becomes damp and weevily the efficiency of the dust is greatly reduced.

Does the number of weevils introduced into a clean sample affect the efficiency of the dust?

To test this matter, 50 weevils were placed in 200 grm. of clean wheat and 400 weevils in 60 grms. of wheat. The experiment was replicated and diatomaceous earth used at ¼ per cent. and ⅛ per cent., but no significant differences were obtained as from 90-100 per cent. mortality resulted in all cases within 7 days.

Does the amount of weevil flour and frass affect the efficiency of the dust?

To answer this question, samples of clean wheat were treated with 1 per cent., 2 per cent., 4 per cent., and 8 per cent. by weight of wheat dust sifted from badly infested wheat. The samples, including a control of clean wheat, were treated with ½ per cent. diatomaceous earth and no significant differences in the rate of mortality were obtained.

The reason why the weevil population in badly infested wheat is not rapidly reduced by the addition of dusts, appears to depend on a number of factors.

First of all the presence of numerous insects may raise the moisture content of the grain and so reduce the efficiency of the dust. Secondly, many of the weevils may be feeding in chewed out grains where they are less likely to come in contact with the dust, and lastly, the eggs and larvae already in the grain will continue to develop and replace those already killed by the dust.

In order to test these points, a sample of weevil infested wheat was sifted so as to remove all the dust and adult weevils. The live weevils and wheat dust were then replaced in the sample, together with ½ per cent diatomaceous earth. Counts showed that in a little over a fortnight, death had accounted for a quantity of weevils equal to the number originally added; there were still however a large number of live weevils present. Successive counts revealed a continued mortality coupled with quite a high living population accounted for by fresh emergences. This experiment is still in progress and the final results are not yet available, but it shows clearly that the dust treatment should be regarded more as a preventive than a cure and that it is difficult to control by this means an infestation once it is firmly established.

Dusting bins, containers, etc.

Where dusts are used for treating bins, sheds, bags, etc., the first essential is to see that all refuse and old wheat has been swept up and destroyed and not just thrown outside. The dusting too must be done thoroughly so as to penetrate into all cracks and crevices. If the treatment can be given with a dust gun, so much the better. If dust is used on weevil infested bags, the latter should be turned inside out and thoroughly shaken and freed from grain, etc. The dust should be then shaken all over the bag and especially into seams and corners. It must be realised that just to sprinkle dust over an untidy heap of bags or between the bags is useless; each bag must be treated individually and thoroughly. The mortality resulting from dust treatment is usually slow, perhaps taking two or three weeks, so that bags likely to contain weevils had better be subjected to one of the more effective liquid dips or fumigation if they are wanted for immediate use.

SUMMARY.

Control weevils by:—

1. Thoroughly cleaning out bins, trucks, bags, etc., before putting in fresh wheat.
2. Destroying all refuse; don't merely throw it outside.
3. Shaking and turning bags after use and hanging them over a wire instead of piling them on the floor near the old wheat.
4. Treating infested bags by dipping in boiling water, White oil, Kerosene Emulsion, or other effective dip, or by dusting.
5. Keep all wheat as dry as possible.
6. Do not mix old and new season's wheat.

ACKNOWLEDGMENTS.

In carrying out the foregoing experiments, I am greatly indebted to the Government Analyst and Mineralogist, Mr. H. Bowley, for providing and grinding various dust samples. Much of the work of counting and sorting the weevils has been done by the Assistant Entomologist, Mr. P. N. Forte, to whom my thanks are also due.

Management and Housing of the Pig Under Wheatbelt Conditions.

W. M. NUNN, Agricultural Adviser.

A great deal has been written and said about the housing of pigs in dairy districts, but very little designing has been done for the wheatbelt areas. The intensive method of sty feeding seems to have been accepted as the general thing, but it is difficult to decide why this should be so. Perhaps the method is unthinkingly copied from the dairy districts or from other countries where space is limited, or perhaps it is thought that solid wooden fences are essential to confine the pig and the project of building roomy yards of this type of construction is too formidable. The solid fence is necessary if the pig is asked to live in a few square yards, but if given room to move about, a netting or mesh fence, with a barb on the ground and another half-way up will be found quite efficient.

When the wheatbelt farmer makes a start in pigs he generally does so with some repugnance. He regards the pig as an unwholesome and dirty animal which lives in a few square yards of malodorous filth. Why the pig should have chosen such a distasteful mode of life is a question that seldom presents itself until by accident the farmer sees for himself a properly run pig farm where the animals are given plenty of room.

Those poky little 10 feet by 8 feet enclosures are all right if used as farrowing pens only, and then only if they are cleaned regularly and disinfected thoroughly after each use. The trouble is that the usual wheatbelt sty, built of bush timber or sleepers with an earth floor and generally poorly drained, cannot be disinfected and so cannot be prevented from becoming a harbour for disease germs and worm eggs.

Most wheat farms are a thousand or more acres in extent, so why not give a few acres instead of a few square yards to the pig herd? Let each sow have something approaching a quarter of an acre to herself and her litter, and let her rear them in that yard without contacting any other pig which might be a disease carrier.

There are three systems of pig raising:—

(a) the open range or paddock system;
(b) the inside or intensive system;
(c) a combination of (a) and (b).

For the wheatbelt farmer, the paddock system is recommended. The combination of the outdoor and the indoor system is used very satisfactorily on a number of up-to-date wheatbelt piggeries, where the owner is in a sound reliable district, and where he is not handicapped by lack of finance and shortage of

labour, but for the average wheat farmer who is now setting out to partake of the still promising returns from the bacon market, to build farrowing pens and expect to keep them clean is merely to ask for trouble. Remember that those who are well established with well drained cement floors and with white-washed walls to their farrowing pens still have to wash them out regularly and scrub and disinfect them prior to each use if they are to be sure of avoiding contamination. They have water laid on and abundant labour to carry out this work, but what chance has the average wheat farmer who is now starting pigs in a comparatively small way, doing all his work himself and carting water, of giving this attention to his sties.

The small pig breeder under wheatbelt conditions therefore, must get right away from the old idea of permanent farrowing pens. He can confine the sow in a pen for farrowing if he is unable to provide her with a separate yard, but it should be a temporary or movable pen so that the same site is not used again and again by sow after sow.

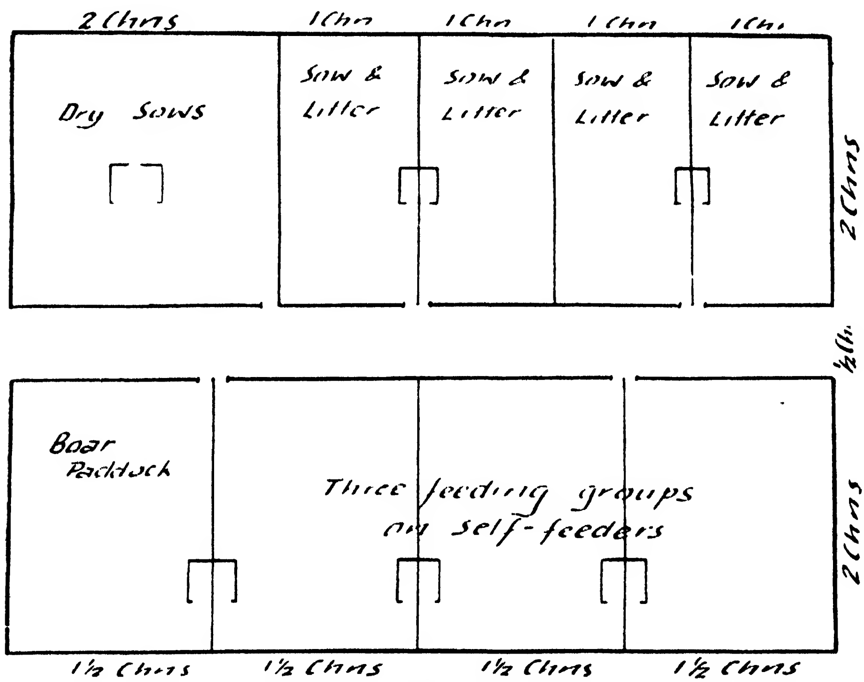

Fig. 1.
Suggested layout for piggery on the paddock system recommended for wheatbelt conditions.

Site.

In selecting the site for the pig yards every attention should be given to drainage and protection from the weather. A sandy type of soil should be chosen rather than a heavy clay type, and it should have sufficient slope to ensure that there will be no residual water after rains. If possible it should be sheltered by timber on the weather side.

Layout.

A suggested layout is shown in Fig. 1. This could be varied considerably to suit the site and the size of the herd, but note the size of the unit. Each sow is to be given a yard one chain by two chains for herself and her litter. The

roomy race between the runs allows easy movement of pigs from yard to yard and with the provision of a few hurdles to span it all the facilities for drafting are provided.

This system of yards could be worked on a slightly smaller scale if finance is limited, but in the long run the larger paddocks will show to considerable advantage.

The ideal layout under the paddock system would provide for the establishment of pastures in these paddocks. It is not intended here to say what should be grown because the possibilities in this respect will vary considerably with the district and the season. Some will be able to plant subclover, peas, lupins, etc., while those in the drier areas could not do better than plant occasionally some wheat, oats or barley. The amount of grazing obtained might be very slight, but the benefit of an occasional working is inestimable from the point of view of cleanliness.

The advantages of the large yards over small cramped quarters are many. They allow of cleanliness in management and a certain amount of grazing as mentioned above. They allow for cleanliness and comfort on the part of the pig, which is naturally a clean animal if given the opportunity, and above all they provide the surest safeguard against disease.

Fig 2.
Type of shelter used at the Northfield Farm of the Inspector-General of Hospitals, S.A.
[From Journal of Agric., S.A., April, 1940.]

Shelters.

A warm draughtproof shelter should be provided in each of the yards. It need not be elaborately constructed, but it should be roomy, well ventilated and entirely free from draughts. The pig is very sensitive to cold and draughty conditions, and serious disease can result from the lack of proper sleepi g accommodation.

Again, when the animal has difficulty in keeping warm a large proportion of the food eaten is used up in providing heat instead of contributing to body weight.

Shelters can be economically constructed in the wheatbelt from bush timber, roof and siding with galvanised iron, scrub or straw. Fig. 2 shows the type recommended for use with the layout in Fig. 1. It should be high enough to permit a man to enter comfortably for cleaning purposes.

A cool, airy shelter of the type shown in Fig. 3 should also be provided for the comfort of the pig under heatwave conditions. A clean wallow, like the clean farrowing pen, is a practical impossibility, in most areas of the wheatbelt, and the type of shelter illustrated with a good depth of straw roofing provides a cool, comfortable spot for the pigs during the heat of the day.

Fig. 3.
A cool airy shelter. Better than any wallow in providing for the comfort of the pig in the heat of the wheatbelt summer.
[W M.N]

Farrowing.

The sow should be put in her yard at least a week before farrowing so that she may become accustomed to her quarters. She should be allowed to farrow in the shelter provided and to live with her litter in this yard until it is time to wean at about 8 or 10 weeks. She will not make a mess of this shelter, because with the room provided she will be able to exercise the cleanly habits that are naturual to her. It is not suggested that this method is better than the correct use of clean cement floored farrowing pens, but is certainly much better than using the unhygienic disease-harbouring .ties which are so prevalent in wheatbelt areas.

Creep Feeding of Litters.

At about three weeks the young pigs commence to forage a little for themselves, and a creep feeder should be provided so that they may supplement the mother's milk as early as possible and become accustomed to the diet they are to go on to after weaning. A creep can be constructed in a dozen different ways and directions are hardly necessary. It is required only that the young pigs can get to the trough while the sow cannot.

Weaning.

At weaning it is best to leave the young pigs in the yard to which they have become accustomed and to remove the sow. The weaners will be less upset and will receive less check this way than they will if they are removed to another yard and meet other pigs. It would be necessary to leave them in the yard only for a few days until they have settled down to their new diet, and they could then be joined with other weaners on the same ration.

Group Feeding According to Weight.

Rations for pigs of various ages or at various weights have been set out in earlier departmental publications. To enable these rations to be correctly supplied it is necessary to group the pigs from weaners upward according to their weights. Pigs from weaning to 50 lbs. live weight should be fed in one yard on the ration suitable to them. From 50 lbs. to about 80 lbs. the ration should contain a lower portion of protein, consequently the pigs of this class should have a separate yard if possible. From 80 lbs. live weight to the finishing baconer, the ration should be a little wider still and should include some chaff to avoid over fattening, and so this group should also be fed separately.

Self-Feeders.

There is no reason why self-feeders should not be used for all groups of growing pigs. The ration recommended for wheatbelt feeding is composed of crushed or ground grain, meatmeal and lime with the addition of chaff in the later stages.

Fig. 4.
A group of self feeders made from 44-gallon oil drums in use on Mr J. Borlase's farm north of Mukinbudin.
[W.M.N.]

The ration is best fed dry, and it can be mixed in the correct proportion for each group and fed through the self-feeder, provided, of course, that a separate feeder is used for each weight group. An enormous saving in labour is thus obtained, and the growing pig is more economical in the use of his food if allowed thus to obtain it as he wants it, instead of fighting hungrily for as much as he can get when the trough is filled twice a day. It is often contended that there is much waste from a self-feeder, because the dry grain is nosed out on to the ground. If the trough is made fairly deep with vertical sides, grain cannot be nosed out of it, and the only grain spilled will be that dropped from the mouth of the pig as it

walks around the trough between mouthfuls. A useful way of minimising this spilling is to erect the feeder on a pedestal 6-8 inches high. Construct it so that the pedestal is only slightly larger in diameter than the trough, leaving only a narrow ledge all round. If the pig has to climb with his fore feet on to this ledge in order to reach the feed, he will stay and eat over the trough rather than climb up and down for each mouthful.

In the construction of the feeder care should be taken to see that the pig cannot comfortably put his feet in the trough itself; that the whole unit is supported on a solid floor properly drained, and that it is roofed so that the feed in both container and trough is kept clean and dry.

For the farmer who expects to do his own cropping and sheep handling and still rear a few baconers, the self-feeding method appears to be the only one. A group of home-made self-feeders is shown in Fig. 4.

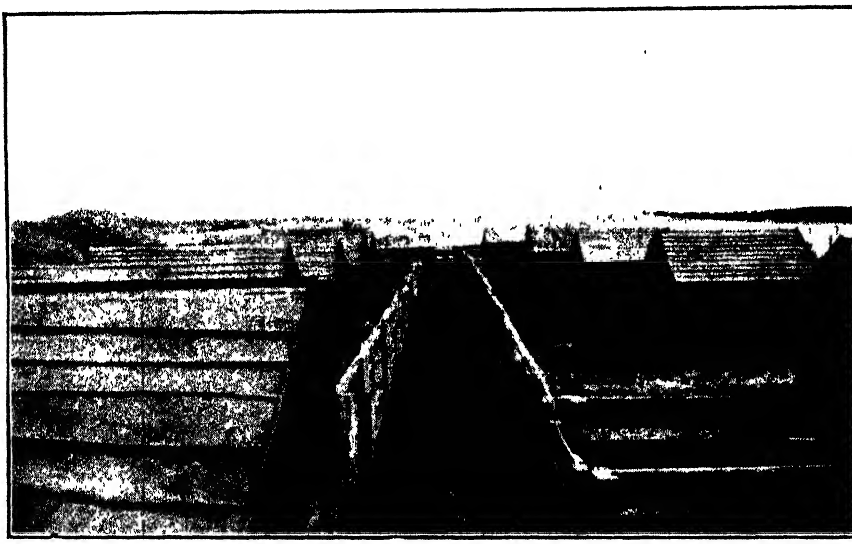

Fig. 5.
Pig yards under wheatbelt conditions showing lay-out on the paddock system
[W.M.N.]

Hand-Feeding for Boars and Sows.

Sows and boars should never be put on self-feeders, or they will become too fat. They should be hand fed and the quantity should be so adjusted that the animals keep in healthy condition. The amount fed should never be more than the animal can comfortably clean up, and the trough should be cleaned out before the next feed is placed in it.

The boar should be provided with a separate yard, and sows should be taken to him as required. Many farmers get on all right by running the boar with the dry sows, and if fences are not the strongest this probably saves a lot of trouble. It is advisable, however, to keep him separate if possible, particularly if the proportion of sows are high and demands on him heavy.

Yarding Provisions.

If above requirements are to be met, it will be seen that the layout should provide for: Sufficient yards to accommodate milking sows as they come in, a yard for the boar, a yard for each of three feeding groups on self-feeders and a

yard for dry sows. This will seem a lot to the farmer starting in a small way, but he should remember that his pig-rearing is to increase, and he should visualise a productive future for it and allow for ultimate expansion to this type of yards, even though his intitial construction is only a small part of it.

Green Feed.

In the drier areas of the wheatbelt very little grazing is available except for about three months in late winter and early spring. That pigs can be satisfactorily and payably reared from weaning to baconers without any green feed has been amply demonstrated. Nevertheless, green feed is the most healthgiving of all foods, and should be supplied by some means or other wherever possible.

Particularly in the case of the brood sow is green feed to be desired, and when grazing is not available every endeavour should be made to supply green fodder if it is only a handful a day. A small irrigated patch of lucerne or other summer-growing fodder is of inestimable value throughout the long, dry, wheatbelt summer.

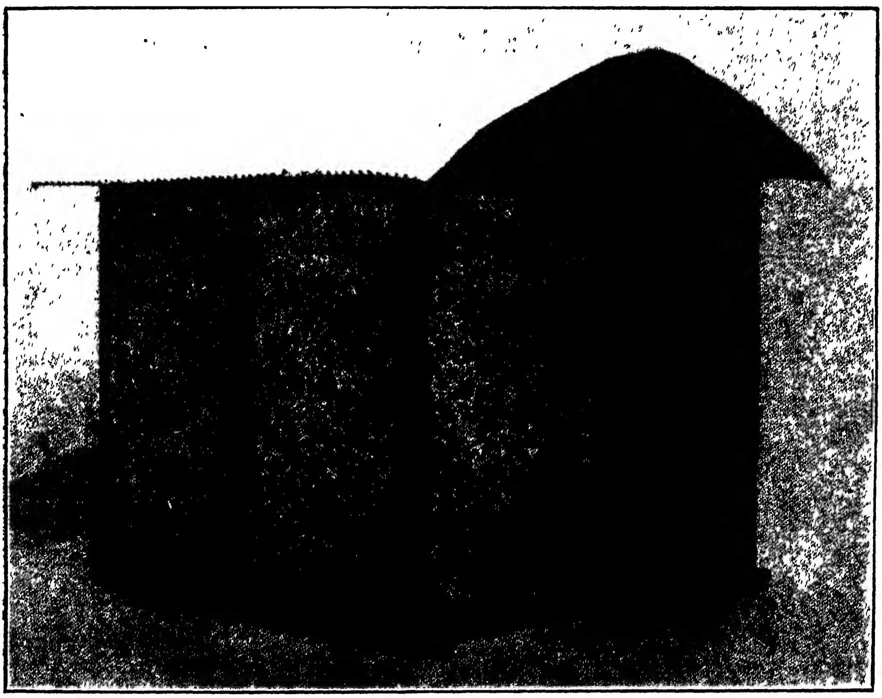

Fig 6
Movable shelter with walls of netting packed with straw.
[From Queensland Ag. Journal, Jan., 1939.]

Electric fencing now enables the farmer to obtain grazing for his pigs in winter and spring, by fencing patches of grass land or of crop. Farmers often seem of the opinion that the pig would simply root out the wheat plant and obtain little value from them if put on a patch of crop. The pig will not root the plants out while there is easily obtainable green picking for him, but he will if left on the same patch too long. The electric fence allows for frequent changes to new areas and enables much increased return from grazing.

Where the electric current fence is used it is necessary to have movable shelters which can be shifted about easily to wherever required. Some types of movable shelters are shown in accompanying illustrations (Figs. 6 and 7).

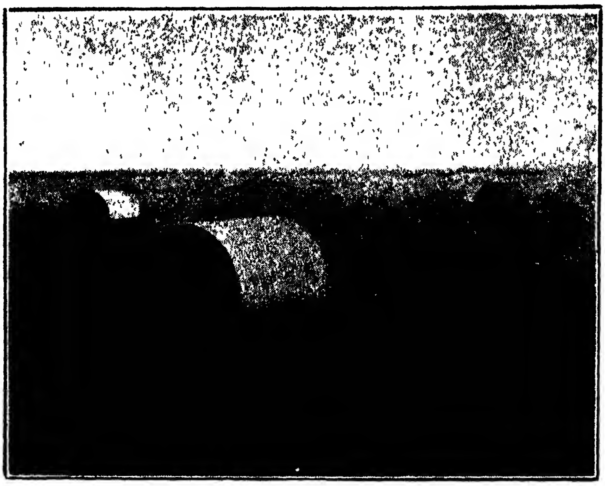

Fig. 7.
Very cheaply constructed portable shelters in use on Mr. N. F. Powell's property at Quairading. The pigs are being grazed on a crop of barley. Mr. Powell uses these shelters in conjunction with electric fencing during the winter months

[W.M.N.]

Summary and Conclusion.

Farmers in the drier areas of the wheatbelt are already very hard worked. They do the greater part of the work of cropping and sheep management themselves, with assistance only at rush periods. Now, nothing daunted, they aim to manage a herd of pigs as well. Finance in most cases is limited, and the project is commenced in a small way with yards constructed by the farmer in spare moments. Under these conditions the construction and management of concrete sties are quite out of the question. Sties of any other description cannot help but become contaminated and so lead to ill-health in the herd, and so the paddock system of yarding pigs is strongly recommended. Roomy yards properly managed, and the intelligent use of self-feeders make it possible for the farmer under these conditions to rear profitable baconers with a minimum of expense and labour.

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Toxic Paralysis (Botulism) in Farm Animals.

C. R. TOOP, Senior Veterinary Surgeon.

Introduction.

During recent years a number of articles have appeared in this Journal recording the original observations of officers engaged in investigating various aspects of the disease known as Botulism or Toxic paralysis as it affects cattle and sheep. In the preparation of this article, in which an endeavour is made to describe the disease, its causes, and the measures which may be adopted for its prevention and control, full advantage has been taken of the information which has thus been made available. Although it may be prevented by vaccination, this disease is still responsible for heavy annual losses amongst farm animals. It occurs over a large portion of the agricultural areas and losses have been particularly severe in certain of the wheatbelt districts. Sheep and cattle particularly are affected; horses to a much less extent. Other animals are highly resistant to the disease. Mortalities on occasions have been reported amongst poultry and birds. Toxic paralysis results from the consumption of material such as carrion, bones, water and fodder, contaminated with a micro organism known as *Clostridium botulinum,* which occurs widely in nature. During its growth in such material this organism produces an extremely potent toxin or poison which, if consumed by a susceptible animal, will set up symptoms of the disease, toxic paralysis, frequently resulting in the death of the animal.

Toxic Paralysis in Sheep.

Toxic paralysis in sheep is almost wholly confined to the summer months, usually making its appearance in January or February and continuing and often increasing in intensity until the onset of the autumn or early winter rains. When green feed becomes available losses from the disease cease abruptly. In sheep, the disease has only been reported during recent years. It was first diagnosed in 1928 and during the years which followed and up till the end of the summer of 1935 it was responsible for appalling losses. A conservative estimate placed these losses during a single season at more than 100,000 sheep; and cases are on record where the losses on individual properties exceeded 50 per cent. of the flock. During the same period losses amongst cattle were proportionately heavy, and in some districts it was difficult to maintain household milk supplies. Although it is not now the scourge of a few seasons ago, toxic paralysis still exacts a heavy toll and as a disease of sheep it ranks second only in importance to infectious enterotoxaemia (braxy-like disease).

Depraved Appetite and Sarcophagia.

The underlying cause of the disease is depraved appetite or pica, which develops during the course of summer and manifests itself in the form of a craving on the part of the animal for such material as decomposing animal carcases and rabbit droppings. An animal affected by this craving will seek out such material and consume it voraciously. Carrion eating is referred to as sarcophagia.

Low Nutritive Value of Pastures.

This condition of depraved appetite is directly associated with the low nutritive value of the grazing available which is especially lacking in protein and carbohydrates—two of the principal constituents of any diet. As the summer advances the

grazing steadily deteriorates in quality, and often in quantity, ultimately becoming inadequate to meet the requirements of the animal which is forced to exist on a low plane of nutrition and commences to lose condition. When this stage is reached, depraved appetite, expressing itself in a craving for carrion, develops—apparently for the purpose of making good what is lacking in the diet.

Mineral deficiency not responsible for depraved appetite.

It was at first thought that depraved appetite was the result of mineral deficiency. This view was based upon the remarkable success which had attended the use of phosphatic licks in preventing "Lamziekte" an identical disease of cattle occurring widely in South Africa. Phosphatic licks were fed extensively in this State but it soon became apparent that they had failed completely to arrest the progress of the disease. It was later shown in experimental sheep that such licks exerted no influence whatever in preventing the development of the depraved appetite.

Toxin Carrion.

The carrion (principally decomposed rabbits; less often the carcases of sheep, cattle, and other animals, left to putrefy in the paddocks) consumed by sheep suffering from depraved appetite is frequently contaminated with *Cl. botulinum.* This micro organism is widely distributed in the soil of farm lands. It often inhabits the intestines of the living animal causing no ill effects. In the living animal the organism is unable to multiply and produce its toxin. When the animal dies, however, and the carcase commences to putrefy it quickly becomes invaded by the organisms contained in the intestine, which now multiply rapidly and at the same time produce a powerful toxin or poison. In a similar manner a decomposing carcase may be rendered toxic as the result of invasion by *Cl. botulinum* contained in the soil with which it is in contact. Sheep consuming such toxic carrion will, after a brief incubation period, develop symptoms of toxic paralysis accompanied by a high rate of mortality.

Decomposing rabbit carcases do not usually become attractive to sheep until 8-10 days old and at this stage they may prove highly toxic. Some conception of the potency of the toxin will be gained from the fact that as little as 1/10 of an ounce of such a carcase may prove fatal if consumed by a sheep. This toxicity steadily diminishes with age but contaminated carcases may still prove dangerous and able to kill sheep even after a period of six months, particularly if they have been shaded after sinking down in the stubble or buried in a burrow or warren and subsequently unearthed.

Polluted water.

Water which has become polluted by a putrefying animal carcase may be rendered highly toxic. Some severe outbreaks of toxic paralysis have been traced to this source.

Contaminated fodder.

On occasions *Cl. botulinum* is enabled to multiply and produce its toxin in vegetable matter. This may occur in the mouldy discoloured sheaves present in the butt of a stack. Chaff cut from such hay may prove highly toxic. In addition, chaff cut from mice infested stacks may be rendered toxic as the result of the bodies of dead mice passing through the cutter. Mortalities associated with contaminated chaff have been observed when this fodder has been fed to sheep as

a supplementary ration during the summer. In some instances chaff which has been proved to be toxic as the result of laboratory tests, has appeared to be of prime quality and in these cases it has not been possible to determine the origin of the toxin.

Rabbit droppings non toxic.

Contrary to a widely held belief that the consumption of rabbit droppings by sheep may result in toxic paralysis, field experiments in which large amounts of droppings were consumed by sheep, have given entirely negative results. These droppings were collected on a number of properties where the disease was actually occurring and the experiments definitely proved such material to possess no toxic properties. Although tests have not been made, the position is probably the same in the case of fowl droppings which are relished by cattle.

The rabbit pest.

Toxic paralysis in Western Australia has been closely linked with the rabbit pest and the years in which the greatest mortality from the disease has occurred have coincided with the years in which rabbits have been present in greatest abundance. The effect of the rabbit in this connection has been two-fold. Firstly by the eating out of pastures it has hastened the rate of their deterioration and has thus contributed to the development of depraved appetite. Secondly the poisoning operations necessary to control the rabbits have provided toxic carrion in great abundance and easily accessible to the sheep. Thus the rabbit has largely provided the conditions essential to the development of the disease and it is probably safe to say that, in the absence of the rabbit, toxic paralysis would cease to be a problem of serious importance in this State. In comparison mortalities resulting from the consumption of carrion derived from other sources (dead sheep, cattle, etc.) are relatively rare. It should not now be necessary to add that the poison bait responsible for the death of the rabbit has no direct association with the development of toxic paralysis. For this to occur it is an essential condition that the carcase become invaded by *Cl. botulinum.*

Symptoms in Sheep.

Affected sheep usually die within two or three days after the appearance of symptoms. They separate themselves from the flock and may be found lying in the normal recumbent position or standing with the head held low. Such an animal, if kept under observation, may periodically be observed to wriggle its tail spasmodically as though flystruck. This is a quite characteristic symptom. When it is driven, the gait of the animal is stiff and short, the back is somewhat roached and the head may wobble up and down. After proceeding a short distance, the animal lies down suddenly as though fatigued. After a short rest it may be induced to rise and will repeat this procedure. Towards the end the animal is unable to rise, and lying in the normal recumbent position, dies quietly without struggling. In some instances a flow of saliva from the mouth may be observed, but salivation in the sheep is by no means a frequent symptom. Occasionally affected animals may linger for a week or more, and in some cases recovery may occur.

The Prevention of Toxic Paralysis in Sheep.

Mineral licks do not prevent the development of depraved appetite, nor do the food supplements such as wheat, oats, chaff, hay or silage, which are frequently made available to sheep during summer in order to maintain their condi-

tion. Consequently these supplements are not effective in the prevention of the disease. Wheat and oats do, however, somewhat delay the development of the craving. It is interesting to note, however, that depraved appetite may be entirely prevented by the feeding of a complete ration, i.e., a ration which will supply all the nutritive requirements of the animal and will therefore contain adequate amounts of protein and carbohydrate. The feeding of such a ration, however, has no practical application on account of its high cost. Two methods of control may be practised, viz.:—

1. By the control of rabbits and the destruction of carrion.
2. By protective inoculation.

The latter method is more generally applicable and is very effective.

Prevention by the Control of Rabbits and Destruction of Carrion.

By enclosing a property with a rabbit-proof fence, carrying out an intensive campaign of rabbit destruction thereafter keeping the rabbit population to a minimum by appropriate measures, meanwhile gathering together and burning all carcases, it is possible to effectively control toxic paralysis. This has been achieved on a number of properties where formerly disastrous losses were sustained. Not only has the disease been eradicated, but the carrying capacity has increased and the sheep have been enabled to come through the summer in much better condition. Such control measures, however, are not always practicable, being limited by such factors as lack of finance and the difficult nature of the country with which it may be necessary to deal. Their application, nevertheless, should always be the objective of all stock owners.

Prevention by Inoculation with Botulinus Toxoid.

Toxic paralysis may very effectively be prevented by inoculation with a vaccine known at botulinus toxoid. This product is prepared from cultures of *Cl. botulinum* grown in the laboratory, subsequently killed by the addition of formalin and then precipitated by the addition of alum which ensures slow absorption from the site of injection thus provoking a powerful immunity response. The immunity or protection against the disease, conferred upon an animal inoculated with botulinus toxoid, is of an extremely high order. In experiments carried out by this department inoculated sheep have been given, without suffering any ill effects, 5,000 times as much toxin as would kill an untreated animal. Such being the case it is extremely unlikely that under field conditions a sheep would ever consume sufficient toxic carrion to break down the immunity which inoculation has conferred upon it.

Sheep should be inoculated at the commencement of summer in order that they may enjoy the highest degree of protection when the danger is greatest. The maximum of immunity is reached 30 days after the completion of inoculation but it is quite strong after an interval of 10-14 days. In addition, the immunity is a lasting one and persists for more than two years. It gradually wanes, however, and as it is desirable that immunity should always be maintained at the highest possible level, annual inoculation is recommended. The cost of treatment is relatively small. Based on a flock of average size it is somewhat less than one penny per head. The dose of botulinus toxoid for the sheep is 5 cc. given in a single injection. This is popularly known as the "one shot" type of vaccine which serves to distinguish it from that type of vaccine with which two injections are necessary. It has the advantage of obviating double handling so reducing labour costs.

Inoculation of Sheep.

It will be found most convenient to inoculate sheep in a small yard capable of accommodating not more than 50 animals, which can be filled as required from larger yards adjoining it.

The following equipment will be required:—a 20 cc. "Record" hypodermic syringe contained in a metal case, six spare No. 18 veterinary hypodermic needles, and a quantity of cotton wool and methylated spirits. Before use the syringe must be sterilised by boiling. To avoid cracking, the metal plunger is withdrawn from the glass barrel. Together with metal case and spare needles the syringe is placed in a vessel of cold water, brought to the boil and kept boiling for five minutes. On cooling, the syringe may be assembled and the needle attached, care being taken to handle only the outside portion of the barrel, the plunger by the handle and the needle by its butt. This will prevent contamination by the fingers of those portions which will come in contact with the vaccine and would otherwise undo the work of sterilisation. Spare needles should be placed in a cup or other vessel containing methylated spirits and will serve as sterilised replacements should the needle in use become soiled or damaged. The syringe case which has been boiled will serve as a sterilised container for vaccine which may be added to it from the bottle as required. The lid will serve as a cover to exclude dust from the yards and must only be removed during replenishment and when the syringe is being recharged. The vaccine will be noticed to contain a heavy precipitate (deposit) which is the active principle and the bottle must always be shaken before the removal of its contents. Vaccine which has been opened but unused at the completion of operations should be discarded. The equipment and vaccine should be placed on a small table, packing case, etc., in a position outside the yard where it will not suffer damage from the sheep and will be within easy reach of the operator. It will be found convenient and confusion will be avoided if the sheep are inoculated in close proximity to the gate and are released as treated, into an adjoining yard. Sheep should be held in the same position as for crutching and the injection for preference should be made in an area devoid of wool such as the inner surface of the thigh or the brisket. The latter site is generally preferred. When the syringe is filled to the 20 cc. mark it will contain sufficient vaccine for the treatment of four sheep. Air bubbles should be expelled by gentle pressure with the finger when the syringe is held upright. The skin at the site of inoculation is cleansed by swabbing with cotton wool steeped in methylated spirits. A fold is taken up between the thumb and forefinger and pierced by a thrust with the needle. The needle should not penetrate deeply but should lie immediately beneath the skin where it can be felt. The required dose of vaccine is then injected by pressure on the plunger.

Apart from slight lameness which may persist for a short period following treatment, inoculated sheep suffer no ill effects. A firm nodule develops at the site of inoculation and a period of months may elapse before it is completely absorbed.

Every precaution must be taken however, to prevent the introduction of infection with the vaccine. Such an eventuality might be followed by considerable mortality. The measures outlined above including the sterilisation of syringes and needles, exclusion of dust from the vaccine, and cleansing of the skin are designed for this purpose.

Measures necessary to Control an Outbreak of Toxic Paralysis.

Should an outbreak of the disease occur amongst uninoculated sheep, inoculation with botulinus toxoid should immediately be performed. After an interval of 14 days an immunity sufficiently strong to prevent further losses will be estab-

lished and the sheep may then be exposed to infection with impunity. In the meantime the paddocks should be searched for carrion which should be gathered and burned. Better still the flock might be moved to a small paddock known to be carrion free and hand fed until the vaccine has taken effect.

Treatment of toxic water.

If the outbreak has been traced to the consumption of water polluted by carrion this may be detoxicated or rendered harmless by the addition of quicklime at the rate of 2 lbs. to 40 gallons after the decomposing carcase has been removed.

Where contaminated fodder has been proved responsible a fresh source of supply should be sought.

Toxic Paralysis in Cattle.

Toxic paralysis appears to have affected cattle in this State for many years and records of its occurrence are available as long ago as 1896. As in the case of sheep, losses from the disease are principally confined to the summer. The same causes which have already been described in some detail operate, viz., depraved appetite resulting from the low nutritive value of the grazing available during summer followed by the consumption of toxic carrion. The consumption of polluted water or contaminated fodder may on occasions also be responsible.

Osteophagia.

In cattle, however, mineral deficiency appears to be a complicating factor. The bone chewing proclivities so frequently observed amongst cattle in affected areas provide evidence of this. Bone chewing is known as osteophagia. Bones like carrion may prove highly toxic.

Symptoms in cattle.

The affected animal may be found lying down and unable to rise or it may still be on its feet when noticed ailing. The animal when standing is reluctant to move and walks with a very stiff, often slow, unsteady gait. Salivation is a very frequent symptom in cattle. In many cases there is a profuse flow of saliva which continually runs from the mouth and may be sufficient to wet the ground beneath. In other cases there is frothing at the mouth or a slight but constant dribbling of saliva. The tongue may be paralysed and protrude from the mouth and there may be difficulty in swallowing or inability to do so. Food may be chewed slowly and for long periods without being swallowed. Often the animal is unable to drink, but when drinking is still possible the water is taken slowly and in very small amounts. An animal showing these symptoms soon goes down and thereafter is unable to rise. Death may occur in a few hours to several days according to the severity of the attack. In some of the more chronic cases the animal remains lying down in the normal recumbent position for a long period and there may be no evidence of salivation or inability to swallow. Some animals may even be able to rise to their feet although the gait remains unsteady. Cases of this kind may in some instances recover especially if assisted by appropriate attention and treatment.

Prevention of Toxic Paralysis in Cattle.

The measures described above for the prevention of the disease in sheep which include the control of rabbits, the destruction of carrion and bones and inoculation at the commencement of summer with botulinus toxoid are equally applicable in

the case of cattle. In addition, where there is evidence of bone chewing, mineral licks with a high phosphorus content should be made freely available. Dicalcic lick, which contains 18 per cent. of phosphoric acid, is recommended.

Inoculation of Cattle with Botulinus Toxoid.

The dose of botulinus toxoid for cattle is 10 c.c. and the same technique as described for the inoculation of sheep should be employed when making the injection. The skin of the bovine is considerably thicker, and more difficult to penetrate than that of the sheep, and it may be found desirable to fit the syringe with a stronger needle. A No. 16 veterinary needle may be used to replace the No. 18 needle used for sheep, and will be found satisfactory. During treatment, cattle should be restrained in a bail or crush. The injection may be made at any point beneath the skin, but it is desirable to choose a site where the skin is relatively thin and loosely attached, such as in the front of the shoulder or over the ribs immediately behind the elbow. In long-coated cattle the hair should be clipped before the injection is made.

Treatment of Affected Cattle.

The mortality rate is high and treatment is only worth attempting in the less acute cases. The animal should be sheltered from the elements and provided with a deep bedding of straw. It should be turned night and morning and attention should be given to watering and feeding. Powdered nux vomica should be given at the rate of two drachms night and morning. For convenience of administration the drug should be mixed to a paste with treacle and smeared on the tongue.

In dealing with an outbreak of the disease in cattle, the measures outlined above for the control of an outbreak in sheep should be employed: *i.e.*, the immediate inoculation of the still surviving animals with botulinus toxoid, the removal of carrion and bones beyond their reach and appropriate action with regard to contaminated fodder or water should this be indicated.

Toxic Paralysis in Horses.

Outbreaks of toxic paralysis in horses are not of very frequent occurrence and are always associated with the consumption of contaminated fodder or water. Horses in contrast with sheep and cattle do not develop the condition of depraved appetite which expresses itself as a craving for carrion or bones. Consequently the major predisposing factor is lacking so far as the horse is concerned.

Symptoms in Horses.

In acute cases the affected animal is found lying outstretched on its side making struggling movements with its legs, at first violent but later becoming feeble. It is usually unable to raise its head, but may make frequent unsuccessful attempts to do so. Large patches of perspiration may sometimes be observed on various parts of the body. Consciousness is generally retained, the animal moving its eyes and ears when approached. An animal in this condition does not survive very long, death occurring within 12 or 24 hours. In the less acute cases there appears to be great muscular weakness. The gait is shuffling and unsteady, and when the animal gets down it often lies outstretched on the ground and has great difficulty in rising, or it may be able to rise only when assisted. Cases of this type may sometimes recover with treatment. Salivation and inability to swallow are infrequent symptoms in the horse.

Treatment of Affected Horses.

A high percentage of horses affected by toxic paralysis die. Affected horses should be supported in slings and attention should be given to watering and feeding. Powdered nux vomica in doses of two drachms should be given with treacle night and morning.

Control of Toxic Paralysis in Horses.

When an outbreak of toxic paralysis appears amongst horses the source of the toxin should at once be sought and removed. It is advisable to discontinue the feeding of the chaff or hay which is being used immediately, and to obtain supplies from another source. Such chaff or hay should not again be fed until evidence proving it to be non-toxic has been obtained. The water supply should be examined for the presence of carrion, and if this be discovered it should be detoxicated by the addition of quicklime in the manner previously described.

The prevention of the disease in horses by immunisation with botulinus toxoid has not been widely practised, and the efficacy of this method of control has not been definitely established. Two types—C and D.—of *Cl. botulinum* have been found to exist in this State. Type C only has been cultivated from carrion, but both types have been cultivated from chaff. Botulinus toxoid is prepared from the C type organism and while it will protect an animal against the type C toxin it cannot be relied upon to protect against type D toxin. If, therefore, chaff contaminated with *Cl. botulinum* type D were consumed, previous inoculation with botulinus toxoid would not prevent an outbreak of toxic paralysis. On the other hand, if *Cl. botulinum* type C were present in the chaff, the result of the inoculation would be entirely satisfactory. The type of organism—whether C or D—which most commonly contaminates fodder has not yet been determined, and until this has been done the question as to the efficacy of inoculation with botulinus toxoid must remain open. In view of the irregular and relatively infrequent occurrence of the disease in horses it does not appear to be a matter of pressing importance. Should the demand warrant it, an effective mixed vaccine prepared from both types of the organism could be produced. Should the inoculation of horses be contemplated, a 10 c.c. dose of botulinus toxoid should be injected beneath the skin of the neck.

Diagnosis of toxic paralysis.

The post mortem examination of an animal dead of toxic paralysis furnishes no information concerning the cause of death. The tissues and organs remain unchanged in appearance. It is therefore necessary to consider the history of the mortality which will generally provide evidence of the consumption of toxic material and to study the symptoms which are fairly characteristic. Considered together, the history and symptoms will in most cases place the diagnosis of the disease beyond doubt.

If fodder or water are suspected, samples of these may be forwarded to this department for testing for toxicity. A 2 lb. sample of the fodder or a pint of water will be ample for this purpose.

SUMMARY.

Toxic paralysis which frequently affects cattle and sheep, and to a less extent, horses, results from the consumption of material such as carrion, water polluted by carrion, bones and fodder rendered toxic or poisonous as the result of invasion by a micro-organism known as *Clostridium botulinum*.

The mortality rate is high and treatment of other than mild cases is not worth attempting.

Losses in sheep and cattle are almost wholly confined to the summer months ceasing abruptly with the advent of green feed.

The low nutritive value of the pastures during summer leads to the development of depraved appetite in sheep and cattle which expresses itself in a craving for carrion which is consumed voraciously and may be highly toxic. Carrion eating is known as sarcophagia.

Sarcophagia is not prevented by the administration of mineral licks or supplementary feeding with wheat, oats, chaff or silage.

Rabbits have contributed largely to the occurrence of the disease by eating out the summer pastures and by furnishing an abundance of toxic carrion when intensive measures for their destruction have had to be undertaken.

In cattle, mineral deficiency which expresses itself as osteophagia or bone chewing, appears to be a complicating factor. Bones may be highly toxic. Where bone chewing occurs, dicalcic lick should be made available.

When it is possible to reduce the rabbit population to a minimum by such measures as the netting of properties coupled with an intensive campaign of rabbit destruction at the same time gathering and destroying all carcases, it is possible to effectively control the disease. Such measures are frequently not practicable.

The disease may be prevented in sheep and cattle by inoculation at the commencement of summer with botulinus toxoid which confers upon the animal treated, a strong and lasting immunity.

Outbreaks of toxic paralysis in horses are isolated and of relatively infrequent occurrence. They do not result from carrion eating or bone chewing but from the consumption of contaminated fodder or polluted water. The same cause occasionally operates in the case of sheep and cattle.

Polluted water may be rendered harmless by the addition of quicklime at the rate of 2 lbs. to 40 gallons after the decomposing carcase has been removed.

The efficacy of botulinus toxoid for the prevention of the disease in horses has not been established.

Muresk Agricultural College.

W. Southern, Principal.

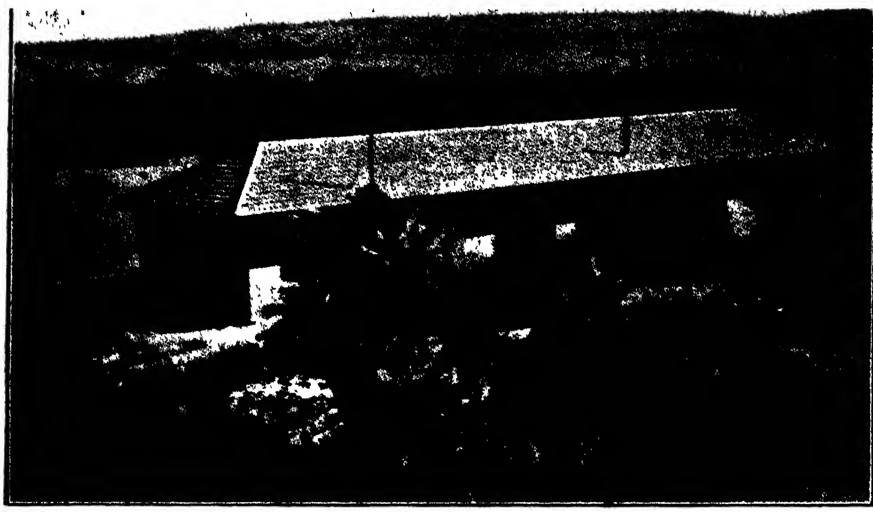
It is now fifteen years since Muresk Agricultural College was opened by the Hon. Philip Collier and work was commenced as a branch of the Agricultural Department.

Its location—at Muresk Siding which is on the Great Southern Railway and three miles south of Spencer's Brook—was chosen, as the position makes it possible to carry out most types of agriculture in an area which is one of fairly assured rainfall.

The Avon Valley is good stock country, enabling instruction in various branches of animal husbandry to be given, coupled with practical experience with the animals.

The farm has an area of over 2,000 acres, a portion of which is hilly, and this formation, together with creeks and rock outcrops, tends to make cultivation of these parts difficult. The student is immediately beset with some of the troubles which may confront him on his own farm.

Cereal and fodder crops are grown, particular attention being paid to subterranean clover. Lucerne and maize flourish under irrigation and these crops supply green feed for stock during the summer. Cereal and meadow hay are produced and a considerable quantity of silage is conserved for the dry period. A great deal of fodder is required since, besides horses and sheep, the College possesses a herd of 60 pure bred Guernsey cattle, pure Tamworth and improved Berkshire pigs and large flocks of poultry. The State egg-laying trials are conducted there. In addition to the above activities Muresk has its own orchard, vineyard and vegetable garden.



The class rooms and Laboratory.

As the College is closely associated with the Agricultural Department, it is naturally very convenient to have easy access to the city.

The main aims of the College are:—

1. To train its students in the science of agriculture, farming practice and in dairy factory work.

2. To raise the general standard of efficiency in farming by holding short courses of instruction for farmers.

3. To carry out experimental work.

4. To raise the standard of stock in the farming districts by breeding and distributing pure breed cattle, pigs and poultry.

The College has its own electric light plant and the water supply is obtained from the Goldfields Scheme. The buildings are situated in undulating and well-wooded country. They are mainly of brick, and being of recent origin are naturally up to date, each student having his own room.

Beyond the fact that the subjects taught are, in the main, different from those of a metropolitan residential college, student life at Muresk is similar to that at those schools.

The students have their sports and other recreations, their library, committees and societies. They are encouraged to conduct their own activities as much as possible, so that in later life they may be able to take their part in the civic life of their district. Muresk students must not only become successful farmers; they must ultimately become leaders in their community.

Practical building construction.

Instruction is given in all phases of agriculture and also in building construction, blacksmithing, saddlery and tinsmithing. For the purposes of instruction students are divided into two groups so that half of them are receiving class instruction and the other half practical farm work. At the end of the week the groups change over.

Each week those on outdoor work are divided into sections; some may be on dairy, others on orchard and garden, and so on. A roster is kept so that each student has his fair share of each job. When rush tasks, such as shearing, are in progress, a special roster is prepared so that all students may gain experience in that work.

In all outdoor work each section works under and with a competent instructor, but as each becomes more experienced he is left somewhat to his own resources. It is not uncommon for a student to be seen in charge of a reaper and binder, for example. In this way he gains confidence in his own ability and learns to shoulder responsibility.

The first year of indoor studies may be regarded as a preparatory one. So many of the students, particularly those from the smaller country schools, have not been grounded in subjects which are essential at Muresk simply because they have not had the opportunity. The first year, then, brings them to a standard at which they can appreciate the second and third year work. In effect, the first year is somewhat similar to Junior Certificate standard but the subjects are ones which the majority of youths have had no previous opportunity of studying. Do not gain the impression that the first year has no bearing on agriculture. It most certainly does. It includes English, a general course in agriculture, botany, mensuration, chemistry, physics, physiology, farm book-keeping, algebra and

wool-classing, together with theoretical and practical work in building construction and blacksmithing. All these courses are not hard, but they do give a student a good grounding for the work that is to come.

In the following year the subjects are continued, although some are somewhat altered. Physics gives place to mechanics, algebra and mensuration to easy farm surveying, and physiology to veterinary work. Animal husbandry and farm management are introduced.

A student mowing clover hay.

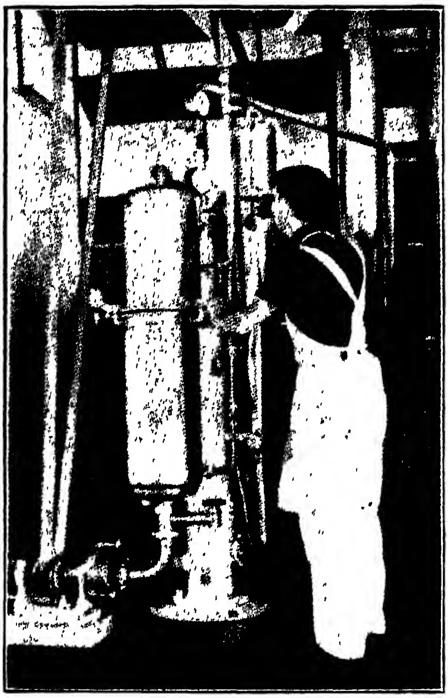
In the third year some similar changes are made. Mechanics for instance changes to farm engineering, which includes studies of farm implements, tractors, etc., while botany is replaced by plant diseases and bacteriology. A course in dairying is introduced.

From these courses you will see that an Agricultural Diploma holder has a very good grip of agricultural work. He is, in effect, a young man with a thorough knowledge of what he will be called upon to do on a farm. It is not claimed that he is an experienced farmer, but he will attack his work intelligently and enjoy it more. He is also not prone to make the costly blunders which so many men make when they take up agricultural pursuits with little or no previous knowledge.

Older farmers must be aware of serious mistakes that they made when they were inexperienced. These trained young men have another big advantage. They have a good knowledge of the latest trends in agriculture and the training which they have received will encourage them to keep up to date with current developments and knowledge.

The main object of colleges such as Muresk is to turn out young men with that most valuable training. After all, most professions and trades insist on preliminary training or apprenticeship. How can agriculture fail to benefit by a similar idea? You will agree that it is harder to become a successful farmer than a good carpenter or a successful member of most vocations you can think of. If it is harder, then preliminary training is all the more necessary.

The Dairy Science Course which was instituted in 1938 is yet another portion of the curriculum. The course was created in order that butter and cheese factory operatives might be thoroughly trained, and with that object in view a very up-to-date butter and cheese factory has been erected at the college. Thus the students in this course receive not only the theoretical side but also are well fitted to carry out manufacturing.



The factory vacreator

Provided sufficient educational standard has been previously attained, those who have already had certain factory experience may cover the work in one year. Non-experienced students are required to attend for two years. The subjects studied include Plant and Factory Management, Factory Book-keeping, Dairy Chemistry, Bacteriology, and others.

As yet no reference has been made to the cost of the course. It has been the policy of successive Governments to bring both courses of instruction within the scope of as many as possible and the fees are, therefore, low. Forty-seven pounds per annum covers all fees for tuition, residence, sport and general medical expenses.

If you analyse these fees you will see that they little more than pay for the cost of the excellent accommodation and board which the students enjoy.

For some years the Education Department has offered places in the nearest Government high schools as scholarships for competition among scholars attending country schools, who pass the Junior Certificate examination. Boarding allowances

at the rate of £24 per annum are granted where necessary to parents who are in receipt of an income not exceeding £300 per annum, or alternatively, £50 for each dependent member of the family.

The regulations governing Secondary School Scholarships and "admissions" to the Perth Modern School and other Government high schools permit those who have passed the Junior in their third year to have their scholarship or "admission" renewed for a further two years. These regulations have now been amended to permit scholars who have passed the Junior examination and who wish to take agricultural pursuits to have their scholarship or "admission" renewed at the Muresk Agricultural College.

This concession will also now apply to all scholars attending Government schools who have passed the Junior examination and whose parents can comply with the above conditions regarding income.

College Swimming Carnival.

Scholarships held at Narrogin School of Agriculture are tenable in the first instance for two years. They may be renewed on completion of the course at Narrogin School of Agriculture for those who desire to take the course for the Diploma in Agriculture at the Muresk Agricultural College. Holders of this scholarship may proceed direct to the second year of the diploma course.

The sons of deceased or seriously incapacitated Australian soldiers may receive assistance from the Sir Samuel McCaughey Bequest.

There is so much misunderstanding as to the qualifications necessary before one may be enrolled for the agricultural course that a statement on this matter may be of value There is no entrance examination nor is it necessary for a student to hold the Junior certificate. He must, however, have received enough preliminary education to allow him to benefit by the courses given. Some find that they are sufficiently advanced to be exempted from the first year of study.

A student must be physically fit and also be recommended by his previous teacher or employer.

The Principal will be pleased to supply any information about the College and its activities.

The Last Shilling – if Necessary.

This is a total war, and Australia's must be a total effort if we are to take our share of the Empire's fight for freedom. In this country we are still privileged to grumble about taxes and other annoying things. In England, which is our front line of defence, they are not grumbling about taxes. They are fighting for their very existence, and living in the hell brought by Hitler's bombers. Not only are they fighting a ruthless foe, but they are paying record taxes to finance their fight.

For them there is no respite. Herded underground, they snatch sleep whenever they can. Tired they walk to work from the shelters, often with the roar of aerial battle in their ears and bombs battering the streets.

How different in Australia. Untouched by the scars of war, life goes on normally, sport and holidays are uninterrupted, and all we know of bombers is the tragic daily story we read of our kinsmen's terrible sufferings, of the slaughter of civilians, men, women and children, and of hospitals razed to the ground.

In Australia we are asked to help the Government find some of the colossal sums of money needed to equip our fighting forces so that when they meet the enemy they will meet him on, at least, equal terms.

A million and a half Australians are subscribing to more than 20,000 War Savings Certificates Groups. They have made a substantial contribution to the £16,000,000 raised so far towards the Commonwealth's war commitments. By weekly payments they have been buying one or more of the £1 Certificates. But now that the first cycle of payments is being completed, many of them show an inclination to "call it a day" and to drop out of their groups.

This attitude is unworthy and dangerous. It is unthinkable that Australians should be ready to dismiss so lightly their obligations to themselves and to their own fighting men who have gone overseas in defence of this country.

The Federal Treasurer (Mr. A. W. Fadden) has issued a warning that any slackening of our effort simply cannot be contemplated. He urges subscribers to Savings Groups to continue, and on an increasing scale, the effort which they have begun so well.

"Everybody," he says, "must get down to the job of making every possible shilling available to the Government. The only alternative to the fulfilment of Australia's loan programme is still higher taxation. I don't say that by way of a threat but as a sober statement of fact which reasonable people will accept and act upon."

As in 1914-18, it must be the Last Shilling—if necessary.

Wastage in Export Grapes.

Preliminary Studies with Potassium Metabisulphite.

T. C. DUNNE.

Introduction.

While the storage and carriage of Western Australian export grapes on the whole has been satisfactory, there have occurred seasons when the condition of some of the fruit after storage left much to be desired. Unsatisfactory carriage of a good deal of fruit of the 1939 export season led to the decision to conduct preliminary investigations with preservatives during 1940 with a view to control of fungal organisms causing wastage.

Data obtained in South Africa (2) had shown reduction in losses following on the use of formalin and of potassium metabisulphite. Early in the 1940 season some trials were conducted with both these preservatives, using late valensy grapes. Inspection showed more injury and more drying of stems with formalin than with the metabisulphite. In view of these results and by virtue of the fact that South African figures had indicated better control with the metabisulphite, it was decided to carry out investigations with this preservative only.

It is emphasised that the studies were of a preliminary nature and that, in view of the small number of cases used, no significance can be attached to the smaller differences reported. The results have, however, shown much definite benefit in wastage control from the use of the metabisulphite under conditions somewhat different from those obtaining in the South African work, and it is felt that some of the data are worth reporting. The reason for recording all the figures from these tests is that they indicate the varying conditions under which some measure of control has been obtained.

Two other points in connection with the results may be noted at this stage. Firstly, it had been reported privately that injury to berries had occurred when metabisulphite was used under Australian conditions. In the tests reported below injury to berries to an extent not greater than about 3 per cent. was found only in a few instances in which the larger amounts of metabisulphite were used. Secondly, it was found that immediately following removal from cold store, the preservative could be tasted on the berries in cases where it had been mixed with the cork. However, with condensation of moisture on the berries as the temperature rose, the metabisulphite was changed to an inert, tasteless substance. By the time the berries had become dry, therefore, detection of the preservative by taste was impossible.

Evidence obtained in other countries in connection with storage of export grapes, shows that seasonal conditions are definitely connected with the amount of wastage occurring. During the 1939 season unfavourable conditions prevailed and considerable wastage losses were frequent. However, in 1940, when these studies were begun, seasonal conditions were favourable to successful storage as concerns wastage and losses.

Experimental.

The potassium metabisulphite used was obtained in the form of crystals, the maximum dimensions of which ranged from 1/4 inch to 1/2 inch. Portion of this was ground in a small mill and separate portions passed through a sieve, 40 meshes per inch, and through a sieve, 100 meshes per inch. These portions were kept in air-tight containers and used in the experiments as were also some of the original crystals.

Ohanez grapes were used for the work. Although the amounts of preservative quoted are based on cases containing about 30-32 lb. of fruit, the units used were actually only half cases. Unless otherwise stated, the preservative was mixed with the granulated cork used for packing, immediately prior to the fruit being packed. Where preservative was applied to the cases top and bottom, half the total amount was spread on the paper before packing began and the other half spread over the top layer of cork when packing was completed. All packing was done in the field.

Vineyard A—Experiment 1.

During the 1939 season, considerable wastage had occurred in the fruit from this vineyard due to discoloration of the berries with which was associated severe infection with ***Penicillium*** moulds. Some cork in which the fruit had been packed

had been salvaged, but no attempt was made to kill the mould spores contained therein. Without the knowledge of the writer, this was the cork in which the fruit used in the experiment was packed.

The intention was to study the effect of preservative on grapes packed under what were considered normal conditions. Only two cases of each treatment were taken.

A separation of rotted berries was made on the day after removal from cool store, and the percentage by weight obtained. A second separation was made two days later.

Packed March 29th.

Placed in cool store March 30th.

Separation 1—July 18th.

Separation 2—two days later.

Treatment.	Separation.	Rotted Berries (per cent. by weight).	
		Unit 1.	Unit 2.
Nil—Control	1 2	42.0 12.1	36.1 13.9
Total	...	54.1	50.0
5 gm. metabisulphite—40-mesh	1 2	3.1 .7	4.7 4.3
Total	...	3.8	9.0
10 gm. metabisulphite—40-mesh	1 2	2.4 .6	3.9 1.5
Total	...	3.0	5.4
10 gm. metabisulphite—5 gm. top and bottom—40-mesh	1 2	9.6 7.5	7.6 1.3
Total	...	17.1	8.9

The control figures showing high wastage illustrate the wastage which may occur from the use of contaminated cork as pointed out by investigations in Victoria some years ago (1). The value of the preservative in controlling wastage is obvious.

Vineyard B.

In 1939 this vineyard suffered mainly from wastage caused by *Botrytis cinerea*.

Experiment 2.

All fruit was sprayed with a suspension of *Botrytis* spores shortly before being packed. A warm dry wind was blowing so that infection of the first few cases may not have been as effective as later on when the interval between spraying and packing was reduced.

Only two cases were used for each treatment. About one month elapsed between collection of data on unit 1 and unit 2 in each treatment.

Packed—29th March, 1940.

Placed in cool store—30th March, 1940.

		Unit 1.	Unit 2.
Separation 1	...	30th June.	1st August.
2	...	3 days later.	3 days later.

Treatment (all infected with *Botrytis*).	Separation.	Rotted Berries (per cent. by weight).	
		Unit 1.	Unit 2.
No preservative	1 2	6 3 *	15 4 8 9
Total	...	...	24 3
5 gm. metabisulphite—40-mesh	1 2	1.7 *	5 5 2 2
Total	...	...	7.7
10 gm. metabisulphite—40-mesh	1 2	2.4 1 8	2.7 1.7
Total	...	4 2	4 4
2 gm. metabisulphite—100-mesh	1 2	3.9 4.3	18 2 9.2
Total	...	8 2	27.4
5 gm. metabisulphite—100-mesh	1 2	4 1 *	3.4 1.8
Total	...	...	5.2
10 gm. metabisulphite—100-mesh	1 2	0.7 3.9	3 0 3.1
Total	...	4 6	6 1
10 gm. metabisulphite—40-mesh—5 gm. top and bottom	1 2	3 6 2.1	2.0 0.8
Total	...	5.7	2.8
10 gm. metabisulphite crystals—5 gm. top and bottom	1 2	4 4 *	18.3 4.9
Total	...	...	23.2
No preservatives	1 2	19.0 10.6	40.5 18.7
Total	...	29.6	59.2

* Figures not obtained.

The data show control of wastage except where only 2 gm. of metabisulphite per case was used and where large crystals were placed at the top and bottom.

Conclusions.

The data obtained from the preliminary investigations reported above confirm the findings of the South African workers concerning the value of potassium metabisulphite in controlling wastage of export grapes during storage. They show, too, that it is effective when used in conjunction with the method of packing prevailing in Western Australia.

It is again emphasised that the small number of units used preclude any significance being attached to the comparatively small differences shown by different treatments with metabisulphite. Some grinding of the potassium metabisulphite usually obtainable does appear to be advantageous

Acknowledgment.

The work reported was carried out with the assistance of the Export Grape Growers' Association of W.A., whose assistance was essential to the investigations. Acknowledgment is also made of the provision of storage facilities by the Westralian Farmers, Ltd.

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Official Milk Records.

G. SLATER.

To the majority of dairy farmers in this State the butterfat yield of their cows takes precedence over the quantity of milk obtained, but to those producing for the whole milk trade, the cow which fills the bucket fills the pocket, provided, of course, that the fat content of the milk has a safe margin over the standard of 3.2 per cent.

There are many Ayrshire, Holstein and Friesian cows and their crosses in the South-West with remarkable milk yields, but their owners have been forced to include a number of Channel Island cattle in the herd to raise the butterfat percentage of the bulked milk, which somewhat depreciates the value of the heavy milking-low-fat cow when placed on the market.

It is most unlikely that the average fat content of Australian Illawarra shorthorn, Guernsey or Jersey cows would fall below 3.2 per cent. and it cannot be disputed that rich milk will always find a ready market and may some day command premium prices.

In the meantime, however, the accompanying list of record yields should indicate that there is no necessity to sacrifice quality to quantity as it will be noted that in every case the fat percentage is over the present standard.

Some breeders may remember the high milk yields recorded in 1925 by two Friesian cows owned by Mr. A. L. B. Lefroy, "Lady Fobes Veeman," producing 16,533 lbs. as a junior four-year-old, and "Bolebek Judith," 14,164 lbs. as a senior four-year-old, but in both cases the fat content was below 3.2 per cent. and for that reason, together with the fact that Friesian cows are no longer officially tested, these productions were not included in the table, and it is considered reasonable that any yields exceeding those shown in the table should not be acceptable as records unless the average fat content equals or exceeds 3.2 per cent.

STATE MILK RECORDS—273 DAYS.

Age and Breed.	Name of Cow.	Herd Book No.	Milk.	Test.	Year Recorded.	Butter-fat.	Owner.
Junior 2—			lb.	%		lb.	
A.I.S.	Glanavon Golden Girl	.	11,558	3·60	1937	421·13	D. Bevan & Sons
Guernsey	Koojan Ideal's Daphne	7250	8,821	5·54	1940	489·13	A. W. Padbury
Jersey	Nooka May Queen	41283	7,888	5·22	1934	412·12	S. P. Herbert
Senior 2—							
A.I.S.	Leylands Topsy	17182	11,226	4·15	1936	465·69	D. Bevan & Sons
Guernsey	Yes of Woodlands	2336	9,024	4·28	1928	386·63	A. W. Wilson
Jersey	Colmyn Buttercup	39319	8,734	5·65	1935	493·84	C. H. Ironmonger
Junior 3—							
A.I.S.	Leylands Melba	17170	12,858	4·44	1937	570·46	D. Bevan & Sons
Guernsey	Morden Lady of Koojan	722	10,296	3·78	1924	389·41	A. W. Padbury
Jersey	Girlie of Sarnia	9902	9,038	4·78	1922	432·78	D. Malcolm
Senior 3—							
A.I.S.	Yallah Farm Maggie 2nd	1612	13,233	3·90	1933	508·87	A. W. Padbury
Guernsey	Koojan Bonnie Jean	1272	9,462	5·75	1930	544·50	W. G. Burges.
Jersey	Mokine Empire Lily 7th	11794	10,164	5·69	1926	579·11	T. H. Wilding
Junior 4—							
A.I.S.	Telyarup Duchess	2504	13,792	3·80	1933	522·84	A. E. Grant
Guernsey	Koojan Ace's Jewel 2nd	5661	13,169	5·19	1940	683·45	A. W. Padbury
Jersey	Crantock White Stockings	56955	8,671	3·68	1940	319·54	Mrs. G. H. Burnside
Senior 4—							
A.I.S.	Hope 3rd of the Hill	Vol. 8	13,423	4·44	1930	606·00	W. G. Burges
Guernsey	Koojan Dulcie	1255	10,036	5·71	1929	573·94	A. W. Padbury
Jersey	Banyule Silvermine 55th	25473	10,887	6·07	1933	660·55	Sabina Vale Stud Farm
Mature—							
A.I.S.	Yallah Farm Maggie 2nd	1272	17,541	3·86	1937	677·21	W. G. Burges
Guernsey	Picton Trequean Flirt	747	13,452	5·18	1928	697·98	A. W. Padbury
Jersey ..	Marinora of Tellaraga	6707	11,509	5·04	1925	584·08	R. H. Rose

Certified Subterranean Clover Seed.

G. R. W. Meadly, Assistant Government Botanist.

Purchasers of Government tested subterranean clover seed are advised to read carefully the information printed on the tags attached to and the slips contained within bags bearing the official seal. These bags may carry a guarantee that they contain seed of a definite strain—either early or mid-season or that they contain seed consisting of at least 98 per cent. pure seeds irrespective of strain. In the second case the factor governing the sealing of the seed is the quantity of impurities such as pebbles, stick fragments, broken, malted or obviously burnt seeds present, and the seed may consist of any strain or mixture of strains. The printing on the tags and slips associated with bags sealed on this basis is always in black type while that of *Strain* certified seed is in red or blue depending on the pure seeds content. The guarantee covered by the sealing is clearly stated on both the label and the slip.

This information is published owing to complaints received from purchasers concerning admixture of strains in what has been referred to as Government certified seed. In every case brought to our notice the seed purchased has been sealed with reference to pure seed content only, the associated tags and slips bearing the following statement:—"The contents of this sack consist of at least 98 per cent. pure seeds, but the attached seal *provides no warranty as to strain.*" The description of the strain in such cases is made by the producer or the merchant.

DEPARTMENT OF AGRICULTURE.

WESTERN AUSTRALIA.

Subterranean Clover Seed.

The contents of this sack consist of at least 98% pure seeds, but the attached seal provides no warranty as to strain.

The Reference Number concerning this seed is } **P.**............

This sack was sealed by

....

Inspector.

Date........... ....

Specimen of tag.

The complaints received substantiate the desirability of purchasing *strain* certified seed, the slight extra cost being more than offset by the assurance of securing the strain desired.

Another practice adopted by some producers is to guarantee that the seed sold originated from areas passed by an officer of the Department of Agriculture as being suitable for the production of certified seed. The official seed certification scheme, however, entails the inspection of areas during the growing period followed by supervision of gathering and cleaning operations, besides estimating the pure seeds content and taking samples (which are held for reference purposes) of every bag. From a strain certification viewpoint the statement is, to say the least, misleading and carries no official guarantee whatsoever. The real article may be described as Government Certified Early (Dwalganup) or Government Certified mid-season (Mount Barker) subterranean clover seed and if sealed and bearing tags to this effect no supplementary description is necessary.

Citrus Growing in Western Australia.

R. C. OWEN, Horticultural Adviser.

Introduction.

Citrus fruits have been cultivated by man for hundreds of years and although oranges are not mentioned specifically in very early history it is more than probable that the legendary "Golden Apple of Hesperides" was none other than the common garden orange. Here in Western Australia there were at least a few orange trees grown by the early settlers, no doubt from the pips of imported fruits, but there were very little, if any, general plantings until the eighties of last century. There are still trees of these early plantings along the banks of rivers in the older settled areas. Some of the first commercial citrus groves were in the Metropolitan area and as far out as the Guildford, Cannington, Armadale and Hills districts near

Perth. They were all of the seedling orange or what we now term "Common Orange" type for it was not till the end of the last century or the beginning of this one that the navel and late Valencia types made their appearance here.

As the State's population grew the planting of citrus increased and during the last forty years there have been periodic fluctuations, sometimes approaching a mild boom, in citrus plantings, until at the present time orange production ranks second only to apple growing in Western Australia's fresh-fruit growing industries.

The following table shows the areas planted and the yield of the various kinds of citrus during the year.

1938-39.

	Area planted. Acres.	Yield Bushels.
Oranges	2,585	322,350
Mandarins	141	17,319
Lemons	422	63,139
Other citrus	36	3,248
Total	3,184	406,056

Citrus trees in the Kelmscott district, and the grower who propagated them from seed over fifty years ago. The tree on the right is a Mandarin tree raised from a seed taken from fruit grown in the Armadale area.

The harvesting period for navels and most other oranges extends from May to November, but the late Valencias which usually mature in October may in a few favoured districts be kept on the trees till the following April so that fresh oranges can be had throughout the year without the necessity for storage. Lemons too are

cropping throughout the year but local mandarins and grapefruit are off the market for several months, and the latter fruit has on occasions been imported from California and Palestine during the last few years.

KINDS AND VARIETIES OF CITRUS.

There are many species belonging to the Citrus family, but only a few are valuable commercially. Those cultivated in this State include:—

1. Oranges *Citrus aurantium.*
2. Mandarins *C. Nobilis.*
3. Lemons *C. limonium.*
4. Pomeloes (including grapefruit) *C. decumana.*
5. Kumquots *C. Japonica.*

In each of these there are many varieties, but of latter years there has been a strong tendency to limit the number of varieties to the few which can be grown commercially and which satisfy the requirements of the consuming public. This is particularly so with oranges, for twenty or thirty years ago any variety, whether Navel, Valencia, Joppa, Queen, Siletta, or even seedling types would command a price, and the seedlings, being more prolific, were probably more profitable than the better class varieties. At the present time, however, any varieties other than navels and late Valencias are classed as "common oranges" and the return to the grower is usually low. In spite of this there are still a number of those out-of-date varieties planted every year and though these might be valuable in marginal areas where a local demand exists, the commercial grower would be wise to plant only those varieties which the public requires.

The following is a brief description of the more popular varieties, but it must be remembered that the qualities vary considerably according to the district in which they are grown, the soil, moisture, and cultural methods employed.

ORANGES.

Washington Navel.—Fruit large, solid and heavy, skin smooth and of fine texture, orange to orange red in colour with the navel marking usually not prominent. Pulp juicy, with little rag, good flavour, seedless. The tree is a strong grower when young, a good and prolific bearer and generally assumes a squat roundish outline when full grown. Foliage dark green in colour.

There are also numerous sub-varieties of navels which have originated as sports from the parent. Included in these are the "Grovelly," "Thompson's Improved," "Navelencia," "Golden Nugget" and "Australian Navel." For the most part these have not the all round good qualities of the Washington and some, particularly the "Australian Navel," are definitely inferior.

Probably the best known sub-variety is *Thomson's Improved.* Fruit somewhat similar in appearance to the Washington. Skin texture very smooth but not necessarily thin, navel scar may be prominent. Pulp crisp but less juicy than the Washington with a tendency to dry out at the stem end. Matures early and is only valuable in some of the early districts.

Valencia Late.—Fruit medium large, roundish oval, skin smooth and moderately thin, yellow orange to orange in colour. Has a tendency to revert to a green colour is left hanging on the trees. Pulp acid till fully ripe, solid, juicy, with only few seeds. Ripens in the spring and in some districts can be left on

the trees till the following April. Old trees have an inclination to bi-annual bearing. Tree vigorous grower with dark green foliage, more upright in growth than the Washington Navel.

MANDARINS.

Trees are generally smaller in growth and foliage than the orange. They are very hardy and bear good crops of small to medium large thin-skinned fruit quite distinct in appearance and flavour.

Emperor.—Fruit medium to large, roundish, irregular and flattened. Skin brittle and somewhat puffy when fully ripe, colour yellow to greenish yellow. Pulp fairly fine, juicy and of good flavour. Tree vigorous and upright with large dark green leaves. Good bearer. With age there is a tendency to produce a mixture of large and small fruits in the one year. Medium early.

Beauty of Glen Retreat.—Fruit medium to large, solid, skin smooth and thin. Colour orange to orange red; skin usually tightly attached to the pulp. Very little rag. Pulp firm, juicy and when ripe is sweet. The fruit colours well before ripening and should not be marketed till the pulp is sweet. Tree vigorous and tends to form a dense head unless thinned out. Very prolific and fruit needs thinning on a heavy crop. Midseason.

Thorny.—One of the best flavoured of all mandarins. Fruit small to medium large according to size of crop and vigour of the tree. Roundish flattened, skin fine, tight and pale yellow in colour. Pulp fine and juicy. Tree moderately vigorous but tends to become dense and bushy. Midseason.

Imperial.—One of the earliest maturing mandarins on the market. Fruit medium in size, roundish flattened, skin fairly smooth and thin, yellow in colour. Pulp moderately fine and juicy Tree upright and vigorous when young, may be only light cropped in some districts. As it matures its fruit early in the season it needs adequate summer moisture to fill out the fruits before the winter rain.

LEMONS.

Lemons are usually vigorous growers and bear fruit throughout the year. They are less resistant to frosts and should have plenty of summer moisture in order to fill out the fruit during the dry mouths. The winter crop—often the heaviest—is usually sold in bulk for factory purposes, but the summer and in-between crops should be cured and sold in case lots.

Lisbon.—Fruit medium large in size, long oval shape, skin yellow and moderately smooth, pulp fine grained and juicy; strongly acid and has few seeds. Tree strong and vigorous, prolific, carrying its fruit practically throughout the tree.

Eureka.—Fruit medium size, good quality, skin bright yellow, smooth and thin, pulp juicy and acid. Tree hardy and prolific, but not so dense in foliage. Much of the fruit is carried on the ends of long growths and is not so well protected from sunburn. Practically thornless.

Villa Franca.—Fruit medium to large, oblong and slightly pointed at blossom end, pulp juicy and nearly seedless. Skin bright yellow and thin. Tree hardy and prolific, almost thornless, foliage strong and abundant.

GRAPEFRUIT.

Grapefruit.—Is a sub-species of the pomelo and so called because of the tendency to set its fruit in bunches. The fruit are fairly large, 3-5 inches in diameter, of roundish flattened shape, pale lemon yellow in

colour. The pulp is regarded as being very wholesome and refreshing, and possessing tonic properties. The fruit may be eaten fresh and has become popular as a breakfast delicacy. It may be used for making fresh-fruit drinks and also for marmalade. In the latter respect it is replacing the Seville orange.

There are several varieties of grapefruit including Triumph, Fosters and Marsh's seedless. The last-named is by far the most widely planted here and has proved itself a strong, vigorous grower, and very prolific. The fruit is carried throughout the tree and usually the best quality fruits are those borne on the inside. Matures from May onwards and in selected districts may be carried on the trees till Christmas time.

KUMQUOTS.

Kumquots are a dwarf species of citrus and a native of Japan. They are very hardy and prolific. Tree is very bushy with small, yellowish green leaves. Very ornamental. Fruit is small—about the size of a small apricot. There are two varieties grown—a round and an oval-shaped fruit. The round type is only suitable for marmalade, but the oval type is excellent for preserving. The demand for this class of fruit is only limited.

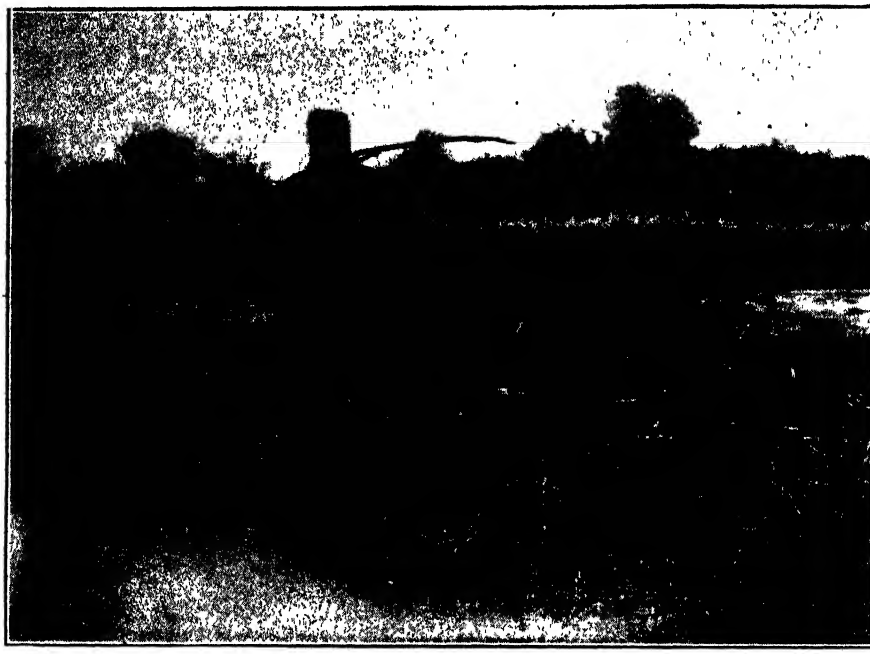
Soil.

The recognised citrus growing districts in the West, range from Mooliabeenie-Bindoon and Chittering in the hills and foothills some forty miles north of Perth, Kalamunda and other centres in the Darling Range eastward, through Gosnells, Armadale, Serpentine, Harvey to Boyanup, Donnybrook and Capel on the coastal plain and over a hundred miles south of Perth. Apart from the three first mentioned districts where citrus culture is the main activity in the fruit-growing pursuit, citriculture is often combined with the growing of stone-fruits and in some places with apples.

Citrus fruits generally are indigenous to those tropical and subtropical regions of Asia and the islands of the Pacific where the climate is equitable and the rainfall is sufficient. The trees prefer a deep well drained loamy soil and they need adequate moisture throughout the year. They will not thrive in shallow undrained soils nor in districts where frosts are frequent and severe. In many of the inland districts of America, Africa and Palestine, and also in parts of the Eastern States of Australia, oranges and other members of the citrus group are now grown in areas that were formerly little better than desert regions. The moisture problem has been overcome by large irrigation schemes and the frost hazard controlled by artificial heating. In Western Australia however, the market requirements do not as yet warrant planting in districts other than those naturally suited to the trees or where local irrigation plants can be cheaply installed.

Undoubtedly the most important environmental factors in citriculture are soil, moisture and temperature, and while the latter two can be controlled within limits by artificial means, the suitable soil is often the limiting factor to the areas planted. In this State oranges and lemons have been planted over a wide range of soil types and in many adverse soil conditions and although the trees have shown their adaptability by making good growth over a number of years, it is only those planted on the deep, well drained and well manured soils of the medium to lighter types, that have maintained their growth, vigor and productivity for thirty years and more. Contrary to general beliefs the citrus trees are not naturally of a shallow rooting habit, for although the finer feeding roots are mostly on the surface regions the heavier roots range outwards and downwards to a considerable depth. They will not, however, penetrate heavy clay subsoil or compacted hardpans nor will they

persist below the permanent water table. Heavy soils do not as a rule produce large or long lived trees but the fruit is often of excellent quality. The lighter soils may not be naturally so rich in plant foods, but they allow of extensive root development and any lack of fertility can be corrected by the application of manures and organic matter. Good deep loams and lighter soils also allow of better and quicker drainage and so approach the ideal for citrus growing.



A contrast in rooting systems. Stumps of orange trees grown on the bank of the river at Gosnells. The vigorous rooted stump on the left was grown on deep alluvial soil with the permanent water table over eight feet down. The stump on the right was grown on the same class of soil, but was not so well drained

Prospective growers who contemplate establishing a citrus orchard should choose a district which has proved satisfactory for the growth of that kind of fruit, or a district which has a rainfall of at least 30-35 inches and a fairly mild winter temperature. If a sufficient permanent supply of fresh water is available the natural rainfall figures are not important. The choice of the actual site must be governed not only by the suitable soil but also by the natural protection afforded from the prevailing winds and severe frosts. Although the surface soil will give an indication do not rely solely on appearances but by means of a soil auger, test the soil and subsoil to a depth of four to five feet. Avoid those areas where a heavy clay subsoil comes near the surface, also shallow soils overlying cemented hardpan or rock. Deep sands and gravelly washes are also objectionable because they lack fertility and have a poor water holding capacity. The surface soil may be sandy provided the subsoil is of a heavier nature, for a light surface soil facilitates tillage, allows free entry of water and does not cake after irrigation.

When preparing the ground for the citrus orchard great care is necessary to see that all large roots are removed to the depth of several feet; this is particularly important if the original timber is marri, blackbutt or other trees which favour the growth of that root-rotting fungus *Armellaria melia* which is so fatal to citrus.

After clearing, the land should be broken up to a depth of ten to twelve inches, and provided the soil is suitable there is not much object in going deeper. Any areas showing hardpan may be broken up by means of a subsoil plough or in extreme cases be explosives. If at all possible it is desirable to have the land cleared for at least a year prior to the planting so that the numerous small roots will have rotted away before the young trees are planted. The extra time and care taken in thoroughly preparing the land is by no means wasted for citrus respond to good treatment and the resultant strong and even growth throughout the plantation will make it well worth while.

DRAINAGE.

Adequate drainage is very important in citrus growing and although many orchards in this State have sufficient natural drainage there are others which need more and deeper drains. All citrus trees dislike cold and waterlogged soils and even if the actual surface soil does not suffer from excess water and become waterlogged there is every possibility that the water level will rise close to the surface during the rainy season. There may be only a small section of the orchard affected, perhaps an outcrop of rock or impervious soil prevents the free passage of water, thus causing a boggy patch, or again there may be a saucer-like depression which collects seepage. The only way to ascertain the need for putting in drains is by actual observation, and if test holes, three to four feet deep are dug in likely places throughout the orchard any serious rise in the water table can be noted during the wet season. A temporary rise after excessive rainfall is not serious but if the water remains within three feet of the surface for more than a week, that part of the orchard would be benefited by more or deeper drains. Where there is plenty of depth of soil drains may be five feet deep; in most cases, however, 3 feet 6 inches to 4 feet deep drains are sufficient provided they are not too far apart. For the sake of economy arrange the drains to effect the maximum drainage with the minimum length; allow sufficient fall to provide a free flow of water but avoid too much slope if there is a danger of scouring.

To facilitate cultivation and also to prevent the soil from drying out during the summer all drains in the orchard should be covered in. Burnt clay or cement concrete tile drain-pipes, although expensive, are easy to lay and give good service; where suitable rock is available a good stone drain can be put in at relatively low cost. Box drains made of timber, when constructed in a workmanlike manner, will give from thirty to forty years of service, but the makeshift drain of saplings, blackboys or temporary materials, generally give trouble and are often only a waste of time and labour.

PLANTING.

After the orchard site is cleared, broken up and drained it is ready to lay out in preparation for planting the trees. The usual systems of lay-out are:—

(1) *The Square System* where the trees in the rows are the same distance apart as the rows themselves. This allows of two ways of cultivation at right angles to each other, it is easy to set out and is suitable for all but the steeper slopes.

(2) *The Septuple System* where trees are equidistant from each other and in groups of seven-six trees forming a hexagon with one tree in the centre. This system allows of three ways of cultivation at angles of 60° to each other, but in no case is the width of cultivation as wide as the distance the trees are apart. The septuple lay out

is very suitable for planting hillsides where it may avoid working straight up and down the slope. With the same distance between the trees it allows 15 per cent. more trees to the acre than does the square system but of course each tree has approximately that much less feeding space at its disposal. Contour planting is now being practised in other parts of the world in an endeavour to avoid soil erosion.

There has been some controversy about the most suitable distance to allow between trees when planting citrus; some favour twenty feet whilst others advocate distances up to 30 feet. The writer considers that twenty feet between trees is suitable for most mandarins and other varieties having upright or dwarf habits of growth, but 24 feet or more is necessary for the larger growing orange and lemon trees. Where the soil is good and the water supply ample all the space is needed to accommodate the top growth, whereas if the soil is poor or the moisture limited the extra distance provides a bigger store of plant food moisture.

The best time for planting citrus trees is when the weather is moderately cool but not when the soil is cold and wet. If the trees are available, autumn planting during April and early May is suitable in frost-free districts; where the trees are not procurable till later or in regions where winter frosts occur, the spring planting in August and early September gives the best results. Prior to planting, remove any dead or injured roots by severing with a sharp knife or secateurs, and have the holes fertilised and prepared to receive the tree. Mix any manure well into the soil and below the root area, and so avoid the possibility of putting the roots in direct contact with artificial manures. Where chemical manures have been applied in close contact with the roots, it is no uncommon thing for the trees to remain dormant for months, and though some may eventually grow, many gradually die out. When setting the tree, spread the roots well out and press the soil closely about them. Do not plant too deeply—deep planting does not mean a deep rooting tree—it may lead to the loss of the tree through *Collar-rot* or *Gummosis* of the trunk. If the trees are set in the ground at the same depth as they originally stood in the nursery, or even slightly shallower, there should be no trouble.

After planting it is a good idea to tie the tree to a stake and hold it firm against winds, and also if the trunk is wrapped with straw, paper or bagging, it will protect it from the direct rays of the sun until such time as the tree provides sufficient shade for itself.

Through the summer the main concern is to control weed-growth and conserve soil moisture. Keep the surface soil near the tree in a good tilth but do not cultivate deep enough to disturb the roots or to dry out the soil at length.

SELECTION OF TREES.

When planting citrus trees due care should be taken to see that none but healthy and vigorous plants are selected. This is a matter of extreme importance as if the trees are unhealthy or weakly in constitution they are unlikely to give the grower satisfaction.

Nowadays citrus are all "worked" or budded trees and as the propagation of these is a specialised trade, it is in most cases better to leave it to the experienced nurseryman. He can usually be relied upon to supply good healthy trees on suitable stocks, but to give him a chance to supply your requirements and to avoid possible disappointment, it is always advisable to place your order some months in advance of planting time.

Of late years there has been a move towards standardisation of citrus types and by "Bud Selection" much is being accomplished. "Bud Selection" means that the buds from which the trees were propagated were taken from parent trees selected for bearing good regular crops of fruit, true to type, and free from hereditary weakness. But selected trees may vary under different environmental conditions, but where conditions are alike they produce groves of even trees bearing regular type fruits. It is too much to expect even bud selected trees grown under unsuitable conditions to produce fruit of equal quality as the same trees grown under congenial conditions.

Apart from the selection of buds much can be done by the nurseryman in culling out unsuitable root stocks and only using those which are strong and vigorous. The rough lemon or citronelle rootstock is favoured by most nurserymen as it is a vigorous grower and produces a good sized tree in less time than most other stocks. It is quite satisfactory under a wide range of soil conditions but some claim that the sweet orange stock is preferable for, although slower in starting, it eventually produces a large and long lived tree.

If the old sweet orange seedlings still growing in many parts of the State are any indication the sweet orange stock is very suitable for the majority of our citrus areas.

Other stocks sometimes used are the sour orange or Seville, which are said to resist collar-rot or gummosis even under wet conditions. They are strong rooting, but must have a deep and rich soil.

Citrus trifoliata is also used and is supposed to have a dwarfing effect on the tree. The few older trees I have seen on this stock are rather unsatisfactory.

For general plantings, trees carrying one years growth from the bud are suitable, although older trees may be used provided they have been suitably "balled" to protect them during transport from the nursery. They are, of course, more expensive than the younger trees. When replacing trees in established orchards it is quite a good idea to purchase the trees one or two years in advance and establish them in a suitable nursery on the place. With careful attention they will make good growth and at a suitable time can be transplanted without suffering any ill effects, and will then have a better chance of competing with the older established trees around them. With care, even old trees can be transplanted, for the writer has successfully shifted trees over thirty years of age and established them in positions among full bearing trees. In this case, however, it was necessary to cut the top growth back in proportion to the roots removed in transplanting.

CULTIVATION.

General cultivation methods in citrus growing are very similar to those carried out in any other orchard, the main objects being to maintain the soil humus by growing weeds or special green crops during the winter or wet season and ploughing them in so that the green material is well rotted before the dry season sets in, and to conserve the moisture and keep down weeds during the dry months of the year. It is much easier to maintain or even build up the humus content of the soil right from the start than to replace the organic matter after the soils have become worked out. As the trees increase in size there is less space in which to grow the green crop, and also the evergreen trees cause a dense shade and limit the growth of the crop during the short days of winter.

Commence the building-up process from the time the orchard is planted, and when the trees are full grown there will be ample reserves of organic matter, so

the maintenance will be much easier. Green crops of the legume family—beans, peas, lupins, tares, etc., not only maintain the humus content but also greatly augment the nitrogen supply of the soil and so make it possible to reduce the quantity of expensive nitrogenous manures used. New Zealand blue lupins or tick beans when planted early in the season make excellent green manure crops; they are easy to plough in and readily decompose in the soil. Whatever crop is grown, even if only natural weed growth, the secret of success is to plough it in early enough so that it decays and allows the cultivation to be completed before the dry weather sets in.

Avoid excessive summer cultivation when the soil is dry, because not only is it unnecessary from the point of view of moisture conservation, but it tends to break up the soil particles and cause loss of humus. This leads to the soil becoming "snuffy" when it will not absorb water readily, and is likely to be lost by erosion. The dust menace too is considerable, and this in its turn will choke the leaf pores and also favour the breeding of citrus red scale.

MANURING OF CITRUS.

Citrus trees when once established will go on producing fruit for years without any special manurial treatment, but eventually they become unthrifty or fail completely. It will then take several years at least of heavy manuring to restore them to a good healthy condition again, so it is far better to keep the trees going steadily by the regular application of suitable manures. It is generally recognised that all fruit trees need an all-round manure containing phosphates, nitrogen and potash, but the proportion of each of these elements and the amount used is largely dependent on the age and condition of the tree and the natural richness of the soil. Most of our soils are deficient in one or more of these necessary constituents but in the absence of experimental data it is impossible to recommend any mixture or fixed quantity of fertiliser for all soils. The whole problem is a question of balance between the necessary plant food elements, and while analysts may determine the chemical constituents of a tree and its crop we cannot guarantee that by placing these constituents in the soil the plants will receive them, for chemical changes take place in the soil and may render some of the substances insoluble or at least unavailable to the plant.

A fertiliser mixture that has given good results and maintained trees in growth and cropping is a mixture of superphosphate, sulphate of ammonia and sulphate of potash roughly in the proportion of 2.2.1. and giving an analysis of P_2O_5 9 per cent., N 8 per cent. and K_2O 10 per cent. Some growers prefer to use bonedust or blood and bone, but these are not balanced and should be fortified with soluble phosphate and potash.

If good crops of leguminous plants have been regularly ploughed in for a number of years the proportion of nitrogen in the mixture can safely be reduced otherwise the trees tend to become too rank and produce a soft and insipid fruit, which does not keep well.

The quantity of fertiliser to apply is largely dependent on the size of the trees but dressings of over 10 cwt. per acre should seldom be necessary, and an average of 4 to 6 lbs. per tree is often adequate. When purchasing manures it is far better to spend say, £10 on a ton of well balanced manure than the same amount on two or more tons of manure containing say only phosphates, unless there is definite evidence to show that only phosphates are required. In other States it is often advocated that sulphate of ammonia or nitrate of soda should be applied at the annual rate of one pound per tree for every year of the tree's age

up to twelve years. That is a tree of more than twelve years of age would receive twelve pounds of concentrated nitrogenous manure every year. In this State where we experience long dry summers and heavy rains during the ripening and maturity period of our orange crops, that amount of nitrogen would be out of all proportion.

Ploughing in a green manure crop of peas and oats. Crops like this turned in regularly every year will do much to maintain the fertility of the soil

Lemon trees which produce heavy crops of fruit and which must be kept growing strongly, will stand heavier nitrogenous manures than oranges and other fruits.

The time for applying manures to citrus is still controversial but as the trees are evergreen and growth is intermittent throughout the year there is some evidence that to divide the annual amount into two or three dressings, say, early Autumn, Spring and Summer is beneficial.

This summer dressing can only be applied where irrigation is possible for it would be unwise to apply readily soluble manures when the trees are stressed for want of water.

The phosphate and potash manures, because they do not readily wash out of the soil, may be safely applied in one dressing and placed as deeply as possible in the soil. If, however, the soil is rich in iron, there is a danger of the soluble phosphate becoming changed to insoluble iron phosphate and thus lost to the plant. In that case the phosphate could be applied as acid soluble basic phosphate which though only slowly available to the plant would last in the soil for a long time. Readily soluble nitrogenous manures may be applied as a top dressing during the Spring or Autumn or with the irrigation waters in the Summer.

IRRIGATION.

As mentioned previously, citrus trees need an ample supply of water, especially through the hot summer, and as 80 per cent. of our normal rainfall occurs between the months of May to October the remaining six months of hot dry weather puts a severe test on water reserves in the soil. There are very few orchards here which can adequately maintain full bearing citrus trees throughout the year without irrigation,

but unfortunately there are many places which through lack of sufficient water supply are denied this necessary irrigation and consequently the trees never have a chance to produce their quota of good quality fruit.

It is surprising just how much drought an orange tree will endure and still mature fruit of a sort, but that fruit is usually small, of poor texture and juice content and effected by drought crinkle. Another effect of drought is out-of-season fruit caused by the trees flowering profusely after the flush of sap caused by Autumn rains.

At present there are no big acreages of citrus in our recognised irrigation areas and practically all the orchard irrigation is carried out from comparatively small private schemes. A few fortunate growers situated on permanent water courses in the hills can gravitate the water on to their orchards with very little cost, but the majority have to instal plants commensurate with the size of their orchards, or in accordance with their available water supply. These supplies are drawn from the local rivers, creeks, soaks and wells and there are various systems of applying the water to the soil.

Where the supply is limited and the orchard is not graded the most economical method for even distribution is through pipes and sprinklers. This method is more costly in power and the initial installation of piping and also necessitates some form of cultivation after each watering, but there is actually less work involved, and there is no soil washing. This method is becoming increasingly popular with citrus orchardists. Some growers use movable sprinklers connected by hoses to the fixed supply pipe, others make use of light piping made from galvanised sheet metal with the sprinklers fixed directly into the pipes. These pipes can be easily shifted about and coupled up again so that when one land has been watered the pipes are set up in another place, and so on until the whole orchard has been covered. Usually the sprinklers are left running for 1½ to 2 hours in the one place and this approximates 1½ to 2 inches of water.

Where the water supply is adequate and the land is better graded the method of open furrow irrigation can be used. The water is caused to flow down one or more open furrows between the trees, the number of furrows depending on the flow of water and the type of soil concerned. Furrow irrigation is more difficult to control unless the grade is even and the subsoil uniform in texture. There is always a tendency for some trees to be over-watered while others might not receive sufficient, if drainage is not sufficient seepage may occur and cause water-logging and consequent damage to the trees.

For the best results use comparatively short furrow leads—not more than five chains—and use the maximum volume of water without causing scouring. The practice of watering citrus by flooding, where the butts of the trees are inundated or kept wet for any length of time should be strongly condemned, for it will eventually lead to loss or damage to the trees through collar-rot and brown rot gummosis

Whatever system of water reticulation is used it is preferable to give a few good waterings at long intervals rather than frequent waterings of short duration. Do not commence irrigation before it is necessary because heavy applications early in the season are likely to chill the ground and may check the activity of the roots and the soil bacteria.

Within a day or two after irrigation the soil should be lightly cultivated to loosen up the surface and prevent any weeds from growing.

PRUNING.

Pruning of citrus is not classed as essential by many growers and while it is true that young trees need very little in the way of pruning excepting to keep the main framework open the older trees are in most cases benefited by some form of pruning to remove the dead and dying fruit wood.

Valencias which have a more free and open type of growth need only occasional cutting to keep the branches off the ground and to remove spent fruiting wood. Navels, however, rapidly become dense and unthrifty if pruning is neglected for long especially as the trees advance in years. The nature of a Navel tree is to expand by throwing out successive layers of fruiting wood and as the older wood outlives its usefulness it slowly dies and is succeeded by new growth. As this new growth extends it gradually shuts out the light and the fruiting wood inside the tree is forced out of existence. The dead wood in itself is harmful because it scratches and blemishes the fruit and also forms a breeding ground for harmful fungous diseases, but the worn out wood is just as harmful because without helping in the necessary metabolism of the plant it is still living and in effect is robbing other parts of essential plant food. This worn out wood should be removed by pruning as soon as it becomes weakly and in doing so the dead wood of the future will be dispensed with.

The outer surface of the tree should be kept sufficiently open to allow light and air to circulate but not too open to allow the direct rays of the sun to penetrate and scald the main branches. The inside fruiting wood may also be thinned to allow the remainder plenty of room to bloom and crop. If the work is done regularly the tree can be kept strong and healthy and that tendency for over-blooming followed by poor setting—usually a sign of a weakened condition—can be overcome.

Mandarin trees, too, become very dense and bushy if not pruned. This leads to the tree becoming weakly and bearing large crops of small fruits poor in quality.

The important thing is to anticipate that too-heavy crop and reduce it by judiciously thinning out the fruiting wood. This will maintain a better balance between fruit and wood growth and so keeps the tree in a healthy and profitable state.

Lemon trees respond readily to good pruning but if neglected they soon deteriorate. To fully realise this it is only necessary to crawl under one—this in itself is a feat requiring skill and determination—and take a look from the inside. There will be seen a dense mass of dead and dying wood interlaced by watershoots and suckers struggling to reach the light. Finally if they ever reach the outside they blossom and carry a bunch of fruit which sways about and becomes hopelessly blemished before it is even half grown.

The lower branches, too, when tangled on the ground interfere with harvesting and cultivation; in the winter they keep the trunk and main limbs so damp that the health of the tree is endangered.

The lemon tree can be kept fairly open, and by regular pruning the fruiting wood should be renewed as soon as it shows signs of flagging.

Even young and vigorous trees can be benefited by using secateurs. Those long rank shoots should be shortened back to stimulate the growth of finer lateral fruiting wood which carries the better quality fruit. By carefully observing the time and effect of this style of pruning from one season to another it is possible to stimulate the production of the summer crop of fruit. In most districts it

takes ten to twelve months from the time of pruning to force the new laterals, carry the blossom and mature the fruit, so that if the pruning is done in the early summer months the resulting crop should be ready for harvesting during the summer of the following year. In an endeavour to stimulate the summer crop the grower must be prepared to sacrifice a portion of the winter crop which will have already set. Control of soil moisture by irrigation is essential to bring a heavy summer crop of lemons to size and maturity.

Healthy navel orange trees grown on sandy loam in the Pickering Brook district. The trees in the background are thirty-eight years old and have occupied their full planting distance so there is now very little room for cultivation. The trees in the foreground are one-year-olds replanted in the place of old lemon trees

It is better to prune lightly every year or two rather than to wait till the tree is a mass of unthrifty wood before cutting it heavily in an endeavour to restore its vigour and fruitfulness.

HARVESTING.

Harvesting the crop is quite as important and needs just as much care and attention as any of the other cultural items. Some growers who are most particular in giving the trees every attention to produce excellent fruit, spoil the effect and actually lose money by careless methods of picking and packing. Oranges, and in fact all citrus fruits, have their juicy pulp protected by a more or less tough skin and can be kept for a considerable time after they are normally ripe provided that skin is not damaged. Once the surface is broken the spores of decay organisms gain access and the fruit rapidly breaks down.

When fresh picked the cells of the skin and rind are full of moisture and are easily bruised or scratched, so great care should be exercised during picking operations. Actually the fruit should not be picked but cut from the trees with a pair of blunt-nosed snips. During the work the operator should wear soft gloves

or at least keep his finger nails closely trimmed to avoid damage to the fruit. Picking bags which are strapped to the shoulders are most convenient receptacles for holding the fruit before it is transferred to the boxes, because they leave both hands free for work. Gently grasp the fruit with the left hand and with the snips in the right hand cut the stem an inch or so back from the fruit, then with a second cut neatly sever the short piece of stem close to the button. By making the two separate cuts the stem which would otherwise die back is removed from the tree, also the cut close to the fruit can be made closer and cleaner with less risk of damage. Fruit should be placed—not dropped—into the picking bag. Do not over-fill the bag as this tends to crush the skin, especially if the picker is working from a ladder. Carefully transfer from the bag to the packing boxes. So far as possible avoid picking the fruit when wet; if this is not practicable then as soon as convenient afterwards spread the fruit out on a bench in the shed to dry. Fruit intended for long transport or for storage is better if not packed immediately, but left for some days in a cool, dry place so that the excess moisture in the skin can dry out. This causes a toughening of the rind and makes the skin less susceptible to injury.

Oranges in commercial quantities do not keep for long periods in store, and it is usual to let them remain on the trees till convenient to market. In districts where the fruit matures early the grower should avail himself of the higher prices ruling to dispose of his crop—within the limits of the market—before the later districts commence harvesting. In this way the loss through windfalls will be appreciably less and the mid-season gluts can in some measure be avoided. The grower in the late maturing districts, however, is faced with a different problem. Most of his Navel crop is ripe during the months of plentiful supplies and he has the choice of marketing the bulk of the crop at comparatively low prices or risking heavy losses by windfalls and breakdowns in an endeavour to keep some of the fruit for the higher prices ruling towards the close of the season. The decision rests with the grower, but if he chooses to keep his Navel oranges on the tree for months after they mature, then it is only natural to expect a proportion of windfalls and decayed fruit.

LEMON HARVESTING AND CURING.

Oranges and mandarins and to a lesser extent grapefruit are marketed within a comparatively short time of picking, but lemons, apart from winter fruits for factory purposes, are better if cured before being sent to market. In this case the fruit should be picked before it is fully coloured or ripe. Pick to size rather than to colour for the market requires a moderately small lemon of about 2¼ inches diameter, and if allowed to fully develop some of the fruit would be oversize and course in texture. Green fruit may be picked when it attains 2½ inch diameter, for in the process of curing it will shrink considerably. Most of the crop will be picked just as it is turning in colour from green to yellow, and this is the ideal stage for curing. As with other fruit careful picking and handling is essential, the main cause of fruit rotting and becoming mouldy in the curing room can be traced to bruises and scratches received in picking.

Grade the lemons before curing and cull out all misshapen, blemished or tree-ripe fruits, for they will not warrant curing, and only occupy valuable space in the chamber. If the market warrants it these culls can be packed fresh or disposed of to the factory for processing either for peel, juice or essential oil.

The curing process is really only a slow reduction in the moisture content of the skin accompanied by a change in colour and in the general texture of the whole fruit. During the process the skins become tougher, but more fine and

thin and assume a soft leathery feel, the rag or white pithy substance practically disappears. There will be some loss in size through shrinkage and this varies according to the type and stage of maturity of the original fruit. There is very little, if any, loss in the actual juice content and the proportion of juice to the total weight of fruit is greatly increased.

The secret of successful lemon curing is to carefully pick the fruit before it is too mature and then place it in a room or container where the moisture reduction can be controlled. If the moisture is lost too rapidly, or too much is lost, the fruit will become shrivelled and will look unattractive; if the rate of curing is too slow there will be a bigger chance of losing a proportion through mould and breakdown.

The curing room must not be draughty and should be kept at a moderately even temperature. Once it was considered that an underground room or cellar was essential for lemon curing, and although very suitable it has no advantage over an ordinary room where the temperature can be kept regulated and the ventilation controlled.

Some growers place the lemons in clean sand or sawdust and either of these give very good results, but both entail extra handling and cleaning. A method which is very much simpler and which also gives excellent results, is to place the fruit loosely in boxes, stack them in the curing room and cover entirely with a light tarpaulin or sacking. A little experience will indicate just the amount of covering necessary and inspections can readily be made to see when the fruit is cured. The usual time for complete curing is from three to six weeks, varying according to the temperature and the state of maturity of the fruit. Once cured the fruit can be marketed immediately, or if the price does not warrant sale, can be kept in the room for weeks or even months without serious deterioration. Lemons picked during the drier months of the year can be cured with very little trouble, but during the cold damp months of mid-winter when the skins are soft and full of moisture it is practically impossible to get consistently good results. Probably artificial heating and air conditioning would solve the problem.

USE OF ETHYLENE GAS.

Citrus fruits showing green colour, if kept for a few days in an atmosphere charged with ethylene gas will rapidly change colour and take on the appearance of normal ripe fruit. This treatment does nothing more than colour the rind and leaves the pulp and juice content unchanged. It is valuable for re-colouring ripe Valencias which have reverted to a green colour through being left on the tees, and is also used for prematurely colouring lemons and navel oranges. Lemons, of course, are normally sold for their juice, which is rich in citric acid, and as this acid is present even in immature fruit, the gas-treated fruit does not differ much from the normal lemon.

Oranges, however, are expected to contain a certain proportion of sugars and to be reasonably sweet to the taste, but immature oranges which have been artifically coloured by gas treatment are often lacking in this respect. The purchaser relying on colour as a sign of sweetness, is often deceived into buying fruit which is not true to nature's label.

There are arguments for and against this gas treatment for colouring immature oranges, but so long as the public are willing to pay higher prices for well coloured oranges early in the season, the enterprising grower will do his best to supply that need. Growers, however, would do well to remember that the consumer once deceived may not be inclined to buy again till late in the season. This temporary loss of public buying would have serious repercussions on the market price.

PACKING.

By far the greater part of Western Australia's citrus crops are consumed within the State, and the small export trade is practically confined to Java, Singapore and Columbo. For local trade the fruit is usually packed in the Australian dump case, the three-quarter dump case, or the three-quarter bushel flat case. For export the standard citrus case holds 1 1/3 bushels but a half citrus box holding 2/3 bushel may be used for lemons.

Before packing the fruit should be graded for size and quality, and firmly packed in the cases, using only those packs which will bring the top layer of fruit level with the top of the case without undue squeezing. The number of fruit in the case should be legibly marked on the outside so that the prospective buyer can see it at a glance and mentally work out the cost of the fruit per dozen.

DISEASE AND PESTS.

As with growing other kinds of fruit or in producing any other type of agricultural commodity there are a number of pests and diseases to contend with in citrus growing. Every year these diseases take their toll and a proportion of the crop is lost entirely or is reduced in value. Practically all pests and diseases have their particular remedy and the careful grower who takes due precautions to combat these pests may find some consolation in the fact that if plant diseases were unknown the production figures would rapidly increase to such an extent that unless new markets were found the monetary returns would be very low indeed.

It is not possible in this article to give details of the diseases which affect citrus trees and fruit but most of these diseases and their control are dealt with in various bulletins and "Journal" articles of this department. These can be had free of charge on application. Growers are advised that if a disease or pest appears concerning which they have no knowledge, specimens should be forwarded together with full particulars to the Department of Agriculture, or to their nearest District Officer. If this is done, correct control measures will be prescribed and possibly the growers will be saved much unnecessary labour and expense.

BUDDING AND GRAFTING.

It has been mentioned earlier in this article that in this State there are still many citrus trees of the older seedling types and varieties of low commercial value. These trees in many instances do not pay for their upkeep and should be dealt with accordingly. Where the tree is unhealthy or unthrifty through disease of the roots and trunk it is a waste of time to do anything else than grub it out and if desirous, replant with a healthy tree of suitable variety. If the tree is still healthy and vigorous it may be worked over to a more profitable variety, and will in a few years time produce good crops of fruit for which there will be a market demand. Apart from the semi dwarf varieties of mandarin trees which may not form good stocks for more vigorous kinds, all commercial citrus varieties can be successfully grafted or budded one on the other. Citrus wood, because it does not callous readily, is not the easiest to graft, but provided the work is done carefully in the early spring—August and September—there should be fair prospects of success. Large trees must be cut back for reworking and if cleft grafted scions are inserted in the cut limbs there is a chance that they will grow. If these scions fail, the cut limbs will send out numerous new shoots which will be fit to bud the following season. When cutting back a tree for reworking always leave a few limbs intact to provide shade for the trunk and main arms. A coat of limewash painted or sprayed on any exposed limbs will do much to protect the bark from sun scald. One of the greatest difficulties in

budding or grafting citrus is to procure suitable scions and budding wood. It is desirable to select scions from mature trees which have proved themselves heavy and regular bearers of good quality fruit but these trees very often only produce fine fruiting wood unsuitable for grafting or budding. When a grower anticipates reworking a number of old trees it is a good idea to prune back a portion at least of the desired bud-wood tree so that it will make strong enough growth to provide scions in time for the contemplated budding or grafting operation.

Budding into vigorous young shoots which arise after the old tree has been headed back, is the most reliable method of reworking citrus. Use the ordinary shield method of cutting the bud and insert in the stock by making a "T" or inverted "T" cut. The bud should be cut from one year old round wood of one quarter to one half inch in diameter. Younger wood is usually too angular to provide suitable buds. Cut the bud to include a thin piece of wood which keeps the shield piece of bark more rigid and facilitates its insertion under the bark of the stock If this piece of wood is removed it may injure the bud itself and often prevents good results. Buds put in during the spring may be forced into active growth by removing the upper portion of the stock immediately the bud has healed in, but buds put in during late summer and autumn are better left dormant till the following spring. If the top growth is then cut back the young bud will have the whole growing season to establish itself.

Young growths from buds and grafts should be suitably protected against injury from strong winds.

SUMMARY.

In conclusion it must be realised that in these days of keen competition and fluctuating markets the citrus grower in common with other primary producers must keep the cost of production at a minimum. This can only be accomplished by growing good commercial varieties on suitable soils in districts where natural conditions are not altogether uncongenial. Plant only those varieties suited to the district, and by scientific cultural methods endeavour to keep all the trees in a healthy and vigorous condition. Use care in picking and handling and by marketing only fruit consistently true to name and grade, build up a reputation for reliability.

Without unlimited capital you cannot keep an orchard. Make the orchard keep you.

Pigs—Management and Feeding.

G. K. BARON-HAY, Superintendent of Dairying.

During the last three years increased interest has been shown by farmers throughout the State in the production of pigs, particularly for the export market. This has been due to two main causes:—

Firstly—prior to the outbreak of war—to the British policy of fixing a price to the producer in Great Britain for bacon based upon the purchase price of offals. Subsequently to the outbreak of war this desirable condition to the Australian farmer has been continued by the arrangement of contract rates for the purchase of pig meats by the British Government.

Secondly—the low price of wheat during recent years, combined with an unpromising world outlook for this commodity.

Owing to the small extent of the local market, farmers are advised to concentrate almost entirely on those breeds and on the carcase weights which are suitable for the export trade.

TYPE OF CARCASE.

In view of the desire for leaner joints in both pork and bacon carcases, it is believed that the type, conformation, and general quality of carcases which meet the requirements of bacon curers will meet also those of the pork trade and vice versa, and the experience with recent shipments to Great Britain indicates that this is certainly so as regards the export trade.

It is undesirable and there is no need to introduce complications into pig production by requiring farmers to produce two distinct types of pigs according to whether they wish to supply the pork or the bacon market. In so far as any variations exist in carcases demanded by these two sections of the industry, such variations are those only of weight and not type, given proper methods of feeding.

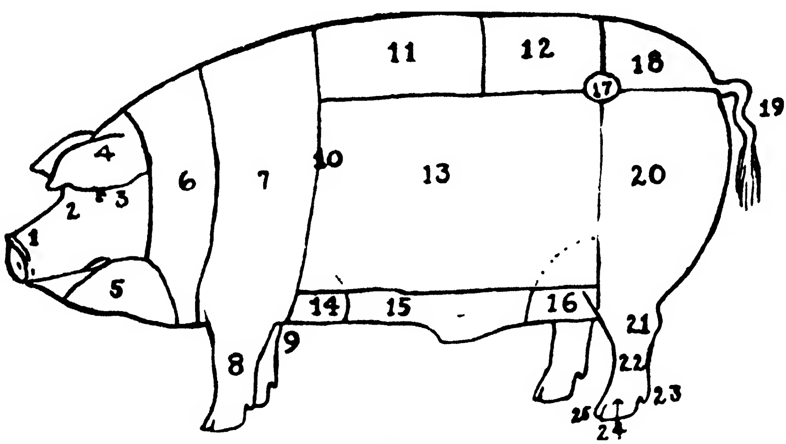


Fig. 1.

PARTS OF THE PIG.

1. Snout or nose.	8. Fore leg.	14. Fore flank.	20. Ham.
2. Face.	9. Chest.	15. Belly.	21. Hock.
3. Eye.	10. Heart girth.	16. Rear flank.	22. Hind leg.
4. Ear.	11. Back.	17. Hip.	23. Dew claws.
5. Jowl.	12. Loin.	18. Rump.	24. Pasterns.
6. Neck.	13. Side.	19. Tail.	25. Toes.
7. Shoulder.			

This is of outstanding importance, as it is often assumed that different breeds or crosses are required to produce animals best suited to the pork and bacon markets respectively.

In order that the description given below of the Standard Pork or Bacon Pig may be understood, the various parts of the pig are indicated in the diagram in Fig. 1.

Carcases for Pork or Bacon should conform to the following specifications:—

DESCRIPTION OF STANDARD CARCASES FOR PORK OR BACON IN WESTERN AUSTRALIA.

The carcase must be that of a properly fed castrated male or virgin female pig.

The middle portion from the first rib to the hip or aitch bone must be long. The fore end must be light, with a light head and neck, and the hams well developed. Ribs must be well sprung, that is to say, they must not slope rapidly from the backbone, but clearly indicate where the back leaves off and the side begins. The line of the back must be slightly arched from head to tail, and not dished or humped over the shoulder. (See illustration 2.) The neck must be of medium length and devoid of crest. The shoulders must be smooth, slightly rounded from side to side over the top and very compact. The back fat should be even, without pronounced thickening over the shoulder, and it should taper slightly from the shoulder to the rump, and should not be greater than 1½ inches at the shoulder in the bacon pig.

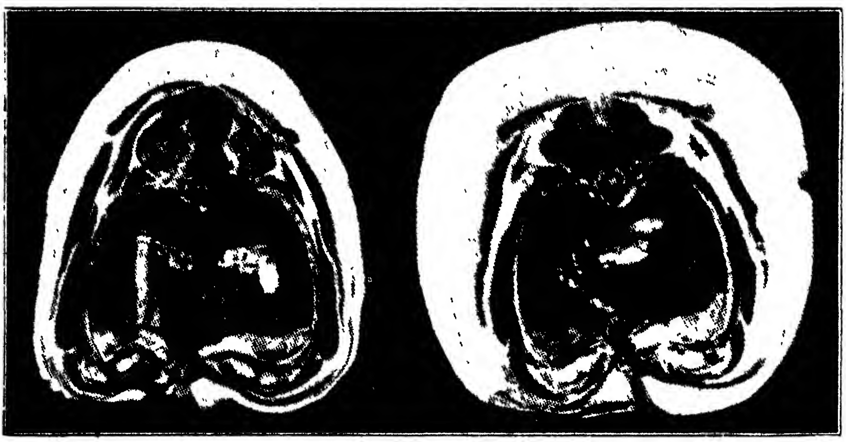


Fig. 2.

A transverse section through the shoulder should be arched. A flat or round section is usually excessively fat, and chest cavity, which holds lung and heart, is restricted. (Min. of Agric. Report on Emp. Pork and Bacon Trades, 1928.)

The underline must be straight and thick throughout its whole length, entirely free from flabbiness or distention of the flank. Thick lines or streaks of fat should be absent from the visible portion of the lean, and indications of leanness must be visible between the ribs.

The shanks must be short, bone fine, and the fore hock and ham free from wrinkles. The flesh must be carried well around the bone, leaving no bareness inside the thigh and well down to the knee and hock joints.

The vertebrae must be of a flesh pink colour and flinty in texture. The proportion of lean to fat must be good. The fat should be white and firm to the touch; when pressed with the thumb, an indentation should be formed which remains visible for a few minutes after pressure has been removed.

The texture of the lean must be fine grained, and not rough or fibrous. There must be no excess of internal fat—the kidneys should have a thin covering of fat.

The rind must be thin, flesh coloured, perfectly smooth, pliable and free from ep-rooted bristles, and must be devoid of any skin pigmentation. There must not any indication of black bristles and no sign of "seedy cut."

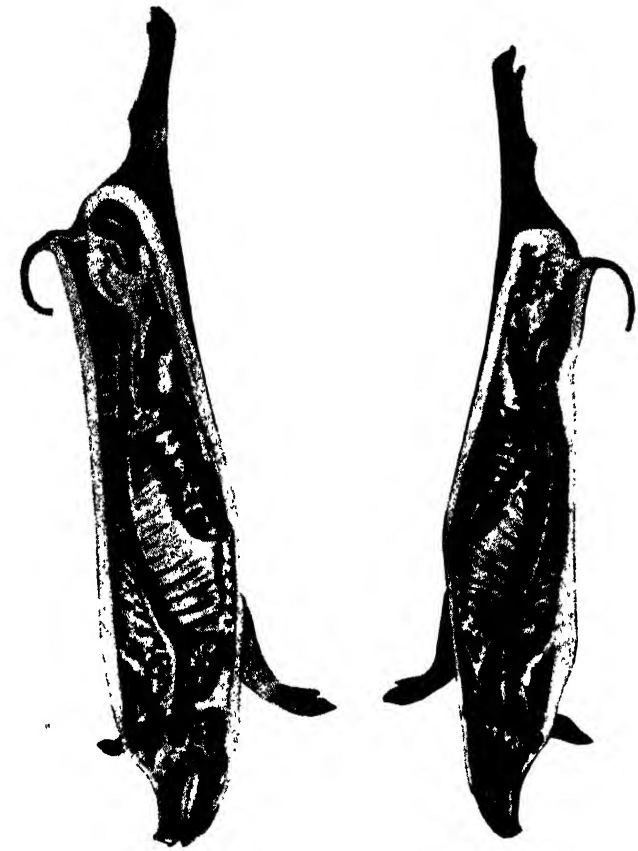


Fig. 3.

A well balanced, well finished carcase, good loin development.

Badly finished carcase, uneven back fat, weak loin.

The following carcase weights are in most demand by the trade, and therefore are most profitable to the producer:—

	Carcase Weight.	Live Weight.
	lbs.	lbs.
Porker—		
Local	50–70	72–100
Export	60–90	95–120
Baconer—		
Local—Grade 1	100–115	143–164
Prime	116–130	165–186
Grade 2	131–140	186–200
Export	135–154	192–215

Farmers are advised not to market porkers of a less carcase weight than 60 lbs. or a greater weight than 90 lbs., although many such pigs are continually being forwarded to the sales. It is more profitable to "run" a pig over 90 lbs. to the bacon stage, as it is from this weight onwards that a pig shows the greatest daily gain. This weight is also an "out size" and not in demand by either the pork butcher or the bacon curer.

It may be unprofitable to continue to feed pigs beyond the weight desired by the trade because these "out-weights" may be difficult to market and, therefore, are "docked" by the purchaser.

The trend during the last few years has been for an increase in the number of Pig Sales being held at country centres. Whilst this system has many distinct advantages, unless farmers are particularly careful with the types of pigs being offered at these District Sales, there are certain disadvantages. The principal of these is a tendency for some farmers to forward pigs to the local market in an unfinished condition requiring perhaps two to three weeks' further good feeding to bring the pigs into their true carcase range. At such sales also it is essential that the quantity of well finished trade pigs should be sufficient to fill trucks for consignment to the main slaughtering centres at present in the metropolitan area. "Unfinished" pigs being presented at a sale have to be used on occasions by buyers to complete truck lots of well finished pigs, and, owing to the possible losses which may occur in keeping these pigs for a further two to three weeks at the Abattoirs, the result may be a general lowering of prices including that of the well finished ones. This condition of affairs, however, will be improved as the serious losses which may be occasioned by it are realised by farmers.

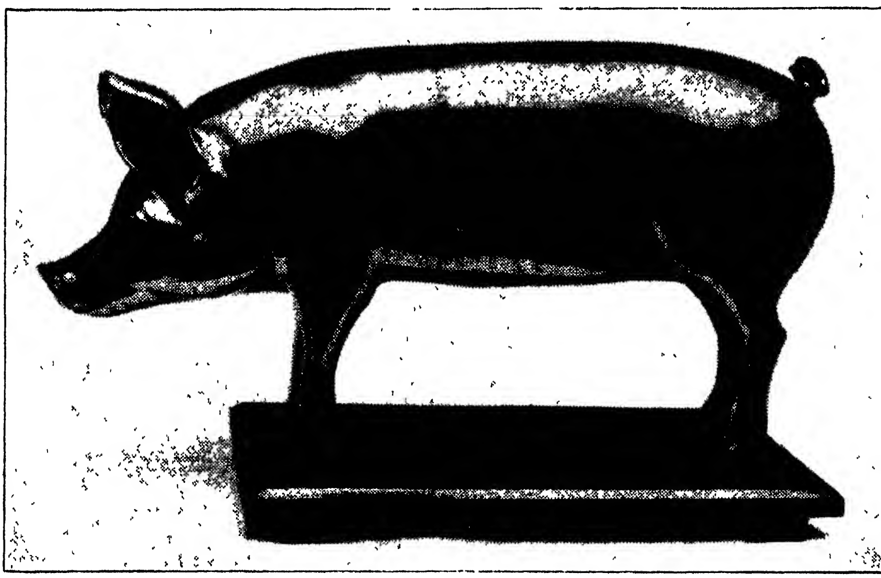


Fig. 4.

Model of Standard Type of Bacon Pig, in chrome-nickel, prepared by Western Australian Branch of Australian Pig Breeders' Association, as a guide to breeders and farmers in the selection of breeding stock for bacon production.

Carcases conforming to the description given above produce a high proportion of the best "cuts" whether as pork or bacon and are the product of selective breeding and correct feeding methods.

With the view of enabling farmers to see the type of pig considered desirable for both local and export trade, the West Australian branch of the Australian Stud Pig Breeders' Association has prepared a chrome nickel model of "The Ideal Bacon Type Pig," which was first exhibited at the Royal Show 1936 and

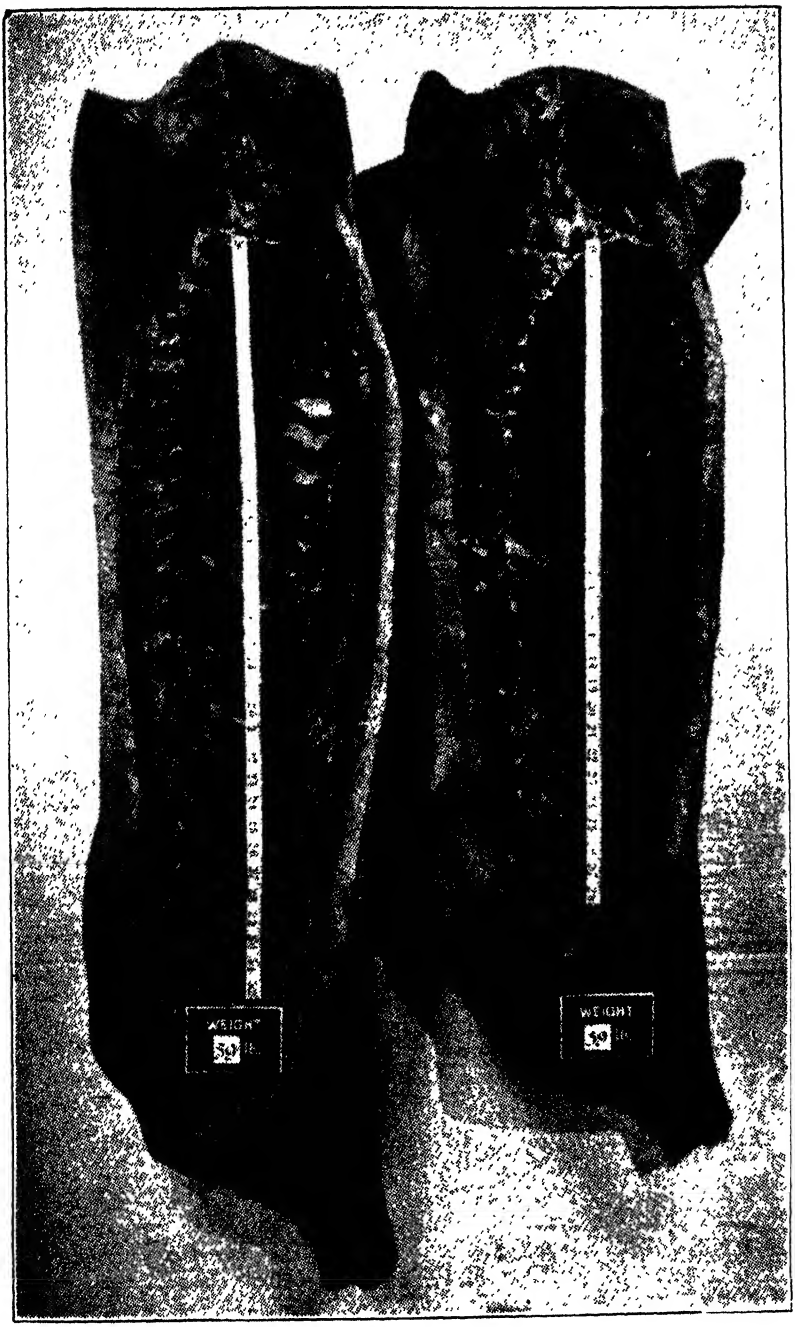


Fig. 5.

Short undesirable side, with too thick a layer of fat along the back, compared with lengthy side. Both the above sides are the same weight.

(Min. of Agric. Report on Emp. Pork and Bacon Trades, 1928.)

subsequently at as many country shows as possible. This is believed to be the first real effort in Australia for breeders to give a positive lead to farmers regarding type, and indicates their belief that within every breed it is essential to carefully select for the bacon type when considering the purchase or sale of breeding stock.

This model pig is illustrated in Fig. 4.

The task of the farmer is to supply the carcase which is described above and which involves two factors—that of "breeding" and "feeding," both of which are considered later in this article.

Breeds of Pigs.

Pigs or swine (*Sus scofa*) have existed in a wild state in Europe, Asia and Africa since the earliest known times, and a close relative is indigenous to the Continent of America. Pigs, however, were unknown in Australia until introduced after colonisation. It is generally accepted that the present day domestic pigs have descended from the wild species. Since the beginning of the Eighteenth Century, a rapid and continuous improvement in the types of a number of breeds of pigs has been effected in England, due to the skill of the English farmer as a stock-breeder and husbandman. Most of the English breeds of to-day have descended from the old English hog with occasional crosses of foreign pigs, particularly Chinese. The domesticated pigs will revert to the wild state if permitted, but the process is comparatively slow, and these pigs do not acquire the solitary habit nor become so fierce as the true wild hog.

Many breeds are recognised throughout the world, but, gradually during the last 100 years, those breeds which have been improved by English breeders have been recognised as of special value for improving native types in various countries. Even in England, however, at least 13 distinct pure breeds are recognised, so that, without special knowledge, the tyro in pig-breeding needs some guidance in the selection of his foundation stock. Four British breeds predominate in Western Australia, and it is proposed to describe only these breeds, as the main points of difference between all breeds are the size of the carcase and bone, the size and shape of head, length and thickness of neck, length and depth of body and legs, and the colour of the skin and hair, details of which may be obtained from the Breed Societies concerned should a farmer for any particular reason be interested in one of these less numerous breeds.

All the requirements of the existing market, both local and export, can be met by the crosses of the four breeds now in the State, and there is no useful purpose served by introducing new breeds and thus rendering the work of standardisation of type more difficult.

BERKSHIRE.

One of the oldest of improved breeds, origin Berkshire, England. Principal improvement in Leicestershire and Staffordshire. The original animal was large, similar to Tamworth, coarse of body, and the colour varied. Marked improvement developed early in 18th century, and was principally effected by Richard Astley and Lord Barrington. Berkshires were first given a separate class at Royal Agricultural Show, England, in 1862. Early writers show that Chinese pigs were crossed with the Berkshire in their improvement. The improved Berkshire was greatly used on native swine in Ireland and Scotland, with beneficial results. This breed is most widely distributed and popular throughout the world, and does well in all climates.

Fig. 6.

Berkshire Boar "Burnham Griqua Gaylad" 4009.

Winner of first prize at the Royal Agricultural Society of England's Show, 1935. Arrived Fremantle by s.s. "Coptic," 9/12/35. Destination -Denmark Research Station. One of four importations made by the Department of Agriculture during 1935.

Characteristics—

Size (relative).—Medium; originally larger than Poland-China, smaller than Large Yorkshire, Tamworth, and Large Black; improved strains similar to these breeds.

Adaptability.—In general adaptability they may be classed at head of all breeds for pork and bacon.

Maturing qualities.—Most excellent. Will fatten at any age.

Grazing and feeding qualities.—Splendid; strong digestive powers enable them to give a maximum return in flesh for food consumed.

Quality of meat.—Excellent pork and bacon. Well mixed fat and lean. Dresses well in proportion to live weight.

Value for crossing or "grading-up."—Unexcelled. Most used in this respect. Great value to refine coarse breeds. Quick growers; early maturers.

Breeding qualities.—Medium to good, but vary according to conditions. If not too confined produce fair to good litters, and are fair mothers. Boars are particularly noted for prepotency, and readily impress the young pigs with conformity and early maturing quality.

Principal points—

Head.—Medium, broad, fleshy, good width between eyes, well dished, snout short.

Ears.—Fairly fine, sprightly, cocked, inclined forward, fringed fine silky hair.

Jowl.—Full, firm, symmetrical.

Neck.—Short, broad, muscular.

Shoulders.—Sloping, freedom from coarseness, thick through chest.

Back.—Broad, long, straight or slightly arched.

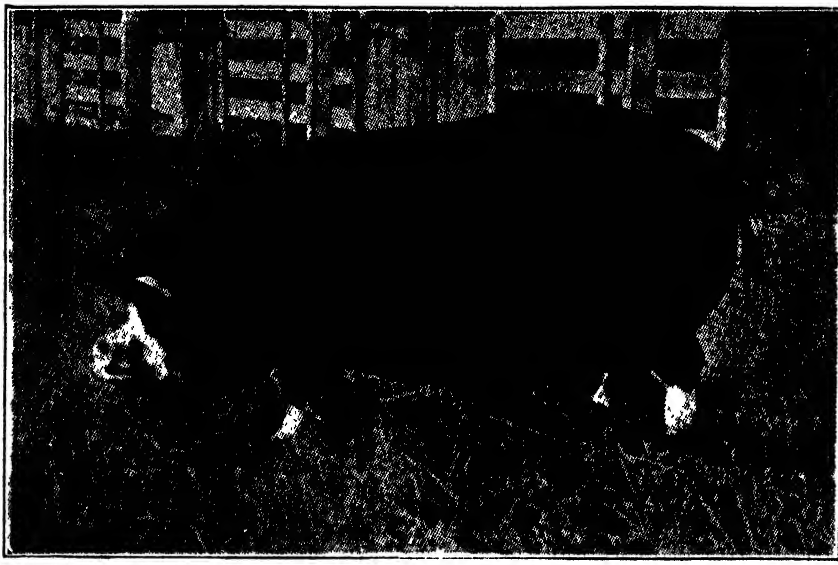


Fig. 7.

Berkshire Sow, "Burnham Griqua Maid" 14006. P.B.H.E.
Litter sister to boar in use at Denmark Research Station, 1935-36. Note fine shoulders and light head.

Barrel.—Ribs well sprung, deep, well let down even side and bottom line deep flank; loins strong.

Rump.—Wide, lengthy, square, showing strength.

Hams.—Deep and thick, well let down, joining back with hock.

Legs and feet.—Short, straight, strong, set well apart. Hoofs erect, firm and strong.

Skin.—Smooth, pliable, freedom from wrinkles.

Colour.—Black, with white blaze on face. White feet and white brush of tail.

Objections—

Snout, long; ears, flopping, coarse; chest, narrow; shoulders, coarse, heavy, open on top; back, drooping; sides, flat, not well let down; loin, narrow or weak looking; rump, drooping; hams, narrow, short; legs, crooked, weak, close together, round bone; feet, weak, flat; hair, coarse, curly, bushy fringe on neck; action, sluggish, clumsy.

Disqualifications—

Colour.—White, irregularly placed. Reddish hair or spots.

During the last twenty years a type of Berkshire pig, specially suited for modern bacon requirements has been developed in Canada. This Canadian or improved Berkshire, as it is known, has been produced as a result of continued selection of bacon type sows and boars, and differs little in conformation from other typical bacon type breeds. The improved Berkshire is rather longer in the snout and lighter in the head and jowl than the older type; the shoulder is finer and more sloping, and the sides flatter, resulting in less loose skin around the belly than in the older pig.

Fig. 8.

Large White Boar, "Wall King David 59th" 91213. S.P.B.H.E.

YORKSHIRE.

Origin Yorkshire, England. Bred from the old English hog, a large white animal. The Small Yorkshire derives its refinement from Chinese crosses, and the Middle Yorkshire from a cross between the two. The Middle Yorkshire was classed separately in 1852. Improvement commenced about 150 years ago. Yorkshire blood widely diffused throughout the world in all white breeds.

Characteristics of Large Yorkshire or Large White.

Relative size.—The Large Yorkshire is probably the largest of the breeds, and one of the heaviest, if not the heaviest. Middle Yorkshire and Small describe their size.

Adaptability.—Good for bacon and pork, especially where large sides are required. Good doers, good for crossing upon weaker types. Inclined to sun scald; prefers cool climates owing to this liability.

Maturing qualities.—Large Yorkshire not so quick as smaller varieties. Requires from six to eight months for market bacon.

Grazing and feeding qualities.—Graze and forage well in cool climate. Gentle disposition. Must be plentifully supplied with food to make economical flesh. Look wretched out of condition, then compare unfavourably with black breeds. Not as hardy as Berkshire. Good growers, especially if sty-fed.

Quality of meat.—Good, especially for large "side" markets. Fat and lean fairly well balanced. The Small Yorkshire excels as a porker.

Value for crossing or grading.—For small fine-boned sows good, will increase size, improve vigour, improve quality of meat, and increase prolificacy.

Breeding qualities.—Good, regular large litters and good mothers. Good tempered, gentle and tractable.

Principal points—

Head.—Long, lightish, wide between eyes.
Ears.—Long, fine, inclined forward.
Jowl.—Light.
Neck.—Long muscular.
Shoulders.—Sloping, no coarseness.
Back.—Long, wide, straight or slightly arched.
Barrel.—Deep, full rounded, well sprung ribs, flanks well let down, long, wide square.
Hams.—Broad, full meat to hocks.
Legs.—Straight and strong.
Feet.—Firm.
Skin.—Cream colour, freedom from wrinkles or dark spots.
Colour.—Pure white.

Objections.—Ears, coarse, flopping; shoulders, coarse; weak back; unshapely hams; weak loins; crooked legs; weak feet; coarse curly hair; action, sluggish.

Disqualifications.—Black or red hair on spots on skin.

Middle Yorkshire differs from Large Yorkshire in reduction in size, weight, length, and has a distinctly short snub nose and short neck.

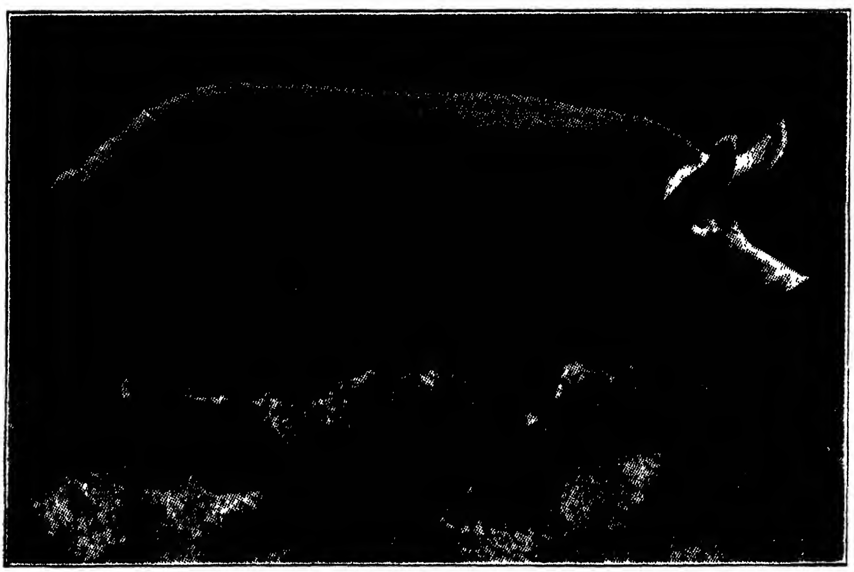


Fig. 9.

Tamworth Boar, "Berkswell Up-to-Date 4th" 78813. S.P.B.H., Eng. Improved type; note hams, capacious body, small head.

TAMWORTH.

Derives name from Tamworth, Staffordshire, England, where they have been bred for a long period. They are probably the oldest and purest of all breeds in England. This (as in all breeds of pure animals) accounts for the wonderful marked prepotency of the Tamworth. At the beginning of the 18th century they

were noted for large proportion of lean meat they produced. Have been greatly improved by selection, but it is generally conceded that no mixture of the breeds has been introduced in improvement. As early as 1847 they were given premier honours in competition with other large breeds at Royal Agricultural Show, England. Following this they went out of favour, but regained popularity from 1880 onwards.

Fig. 10.

Tamworth Gilt, "Inge Velvet" 253930. S.P.B.H., Eng.
Imported for Muresk Agricultural College in 1935.

Characteristics—

Relative size.—At least second to Large Yorkshire, and in some cases even larger. Hardihood and vigour in keeping with size.

Adaptibility.—Unexcelled.

Maturing qualities.—Comparatively slow, not equal to the smaller or refined breeds.

Grazing and feeding qualities.—Excellent grazers, wonderful foragers. Exceptionally hardy; will stand forced feeding. Very suitable open conditions. Powerful digestion, but must not check growth.

Quality of meat.—Excellent on account of leanness. Exceptionally good to cross with to improve meat for bacon. Less waste in cooking, good flavour.

Value for crossing or "grading up."—Excellent when crossed with small compact over refined grade sow. Impart size, development, vigour, and prolificacy, more and better meat (very big factor). Good growers. Good mothers. Excellent travellers to market.

Breeding qualities.—Unexcelled for prolificacy and hardiness, freedom of parturition troubles. Ideal mothers, rarely overlies her young, great defenders, good sucklers.

Principal points—

Head.—Long, lean, light, tapering to snout.

Ears.—Moderate size, fairly erect, pointing forward.

Jowl.—Light.

Neck.—Long, rather deep than wide, tapering.

Shoulder.—Sloping, good thickness through heart.

Back.—Moderately wide, long, slightly arched.

Barrel.—Long in coupling, deep ribs, well sprung.

Rump.—Deep, fairly full, rounded.

Ham.—Large, gradually rounded off rather than square.

Legs.—Moderately long, strong, firmly placed under body.

Skin.—Smooth, plentifully covered with hair.

Hair.—Freedom from coarseness.

Colour.—Bright golden red, no black.

Objections.—Shoulders coarse, open at top. Ribs flat, weak coupling, shallow body.

Disqualifications.—Black or white hairs. Black skin.

BREEDS RECOMMENDED.

As a result of a Conference held in 1930 at which Representatives of Breeders, Curers, and the Royal Agricultural Society were present, it was recommended that the Berkshire and Tamworth breeds and their crosses were most suitable for the production of bacon and pork under Western Australian conditions.

During 1930-35 a number of experiments have been carried out with these two breeds at the Denmark Research Station, Muresk Agricultural College, and on Mr. W. G. Burges's farm, "Tipperary," York, with a view to ascertaining further information as to the desirability of these two breeds in competition with the Large White Yorkshire breed. As a result, the recommendation is confirmed that the most useful pigs under West Australian conditions are the Tamworth and the Berkshire. Whatever breeds are utilised, however, types of sows and boars should be selected which conform to the bacon type, that is, good length, light shoulder, well developed ham, light jowl and small head.

In further trials where the carcases of various crosses have been forwarded to London, both privately and during the two years that the Perpetual Executors and Trustees Export Pig Trophy was being competed for, the London reports indicate that the Tamworth, the Berkshire, and their crosses were able to produce carcases, suitable for the British market. It is not suggested that the Large White and its crosses are not suitable for this purpose and do not produce a desirable type of carcase, but, even in this breed, selection is necessary to obtain a typical bacon carcase, and the average results show no greater percentage of high quality carcases than in the Tamworth-Berkshire cross. Moreover, curers in this State and in Queensland advise that this cross is suitable for their purposes, and a large and profitable export trade in pork has been built up by New Zealand principally with pigs of the Tamworth-Berkshire cross. Therefore, under West Australian conditions the recommendation is made that good type breeding stock of these two breeds should be purchased by small farmers intending to maintain a few sows.

BREEDING METHODS.

In-Breeding.

Generally speaking, in-breeding with pigs must be handled most carefully. No other class of stock shows the disastrous results of careless in-breeding so quickly, the first evidence being the birth of blind pigs, hermaphrodites, and abnormal individuals of all kinds. Mainly, however, the loss is through the weakening of the strain.

In-breeding is employed to improve quality, whilst out-crossing—the opposite of in-breeding—produces strength. In the hands of the expert breeder, in-breeding has its place in the development of type, quality and strength. The commercial farmer, however, would be well advised to depend upon the frequent introduction of fresh blood in the form of pure bred boars of the right type for improving his breeding stock.

Line-Breeding.

Although differing only in degree from in-breeding, careful line-breeding has been the origin of many of our best strains of pigs to-day. In this case the blood lines are similar, but the individuals are more distantly related.

Cross-Breeding.

The crossing of almost any two pure breeds of pigs usually will result in increased strength and vitality of the offspring. When two breeds of the same type are crossed, this same type is secured in the offspring with increased vigour. Such pigs invariably prove good "doers," thrifty, easy to feed and finish. The Tamworth-Berkshire cross is favoured, the sire being Tamworth. Because it is difficult for a farmer to maintain the two breeds and thus keep ensured a supply of pure bred females, cross-breeding in the true sense is not a widely followed practice, although, if pure bred sows are available for this purpose, the best results are obtained. The crossbred pigs should be used for market purposes only, and there is always the danger of utilising the crossbred progeny as breeders—a practice which frequently is followed by unsatisfactory results.

GRADING-UP.

The method of breeding which seems to offer the greatest source of revenue from the least expenditure for breeding stock is that of breeding up from common or grade stock through the continued use of pure bred pigs of one breed. Such grade brood sows, however, should not be selected as mothers unless the type which the farmer desires is strongly in evidence. Sows of this description can be procured for a small cash outlay, and, provided care is exercised in selecting a suitable pure bred boar, very rapid progress can be made in the development of a strain of bacon pigs which will produce carcases very little the inferior of the true crossbred or pure bred pig. This method of breeding pigs for market can be relied upon to give increasing numbers of pigs of the right conformation and type, and the percentage of high quality carcases will increase as the concentration of blood of the bacon breeds is increased through subsequent matings. The key to this system of breeding is the selected pure bred boar.

It is regrettable that there are a large number of crossbred boars still being used for breeding purposes, and, when it is realised the large number of pigs which such a boar can produce in even so short a period as twelve months—running into several hundreds—the folly of breeding from such an animal becomes very evident.

"Grading-up" therefore means using pure bred males of one breed for a number of generations. By starting with the ordinary sows available, and continuing the policy without deviation, a concentration of the desirable blood represented by the boar is obtained. By this means the "mongrel" blood is bred out, and a fixed type obtained. To ensure the improvement being continuous, the best sows from each generation should be selected as brood sows, and mated to another boar of the same breed as that started with; the breed of boar should not be changed, otherwise years of careful breeding may be wasted, and the whole process of grading up would have to be repeated. By such a definite policy as that outlined above, a pig breeder builds up good type and quality, shapely, quick-maturing and profitable commercial pigs.

SELECTION OF BREEDING STOCK.

General Considerations.

Once the decision has been made as to the particular breed that is to be used, then comes a very important phase in pig production—the selection of the proper sows and boars. With dairy cattle to-day, an animal is bought on its appearance, pedigree and production record. In some countries it is possible to select pigs on a somewhat similar basis, as a result of recording schemes being officially conducted in those countries. Such schemes are costly to conduct and require large numbers of recorded stock to make their conduction possible, and for this reason have not yet been introduced to Western Australia. These schemes enable breeding stock to be selected on the following three factors:—

(1) the ability of a sow to rear a large litter up to weaning stage;

(2) the rate of growth up to the bacon stage;

(3) the quality of the finished product.

In the absence of such recording schemes, animals can only be selected on their pedigree and conformation. The farmer who breeds his own sows is therefore in an advantageous position, as he is able to keep a record of litters, and need keep breeding sows from only the good performers.

In the first instance, a breeding animal should have excellent health and conformation. There are several external characters which are good indications as to the health and constitution of an animal. The hair should have a healthy appearance and be of the right colour, eyes bright and full of life, and also good blood circulation at the extremities, such as the ears, tail and feet. In white pigs the skin should have a rosy colour, and should not be dry, hard and "dead" white; the latter indicates absence of sufficient blood. Hair without any lustre and a pale colour of the mammary glands and scrotum are indications of poor health, and such animals should be discarded.

For a good conformation the breeding animal should show firmness and compactness with medium feeding. Soft and over-developed pigs are undesirable. The skin should be firmly drawn over the body, without wrinkles, and have a good covering of hair between the front legs and over the hams at the back of the sexual organs. Glossy, smooth hair is an indication of good food utilisation. Soft, thick, flabby ears and weak pasterns are bad signs.

THE HERD BOAR.

The herd boar may be responsible for up to 1,500 progeny during his life, and therefore his selection is a matter of paramount importance to the pig breeder.

On no account should anything but a pure bred boar be considered, and they can always be purchased at reasonable prices from breeders. If it is possible to obtain the information, a boar from a large litter, and from a strain of sows which throws large litters, should be chosen. In addition to pedigree, however, and whatever the breed, there are certain sex characters which should always be manifested by the herd boar. The head should be strong, is longer than that of the female, and should exhibit pronounced masculinity. After about five months of age, males show an increase in the size of the head, and thickening of the bones, thus in the mature boar one expects a strong head with what may be regarded a tendency to coarseness, as shown by the thickness of skin and coarse type of hair. Some boars develop shields, which are heavy coverings of tough hide on the shoulders. This is very undesirable, and a boar with smooth shoulders, or whose relatives have this character, should be selected. Although the tendency is for the male to become heavier in front than the female, this should not be excessive, as this character is inherited and passed on to the progeny. The scrotum should be well developed with two testes of equal size. It is fairly common to find young boars with only one testis, and since this is a hereditary condition, such boars should not be used for pedigree breeding.

If a boar is selected as a weaner, he should be fed intelligently with muscle, bone, nerve-tissue-forming foods or protein, his normal growth not checked, and given plenty of exercise. At four months it is advisable to separate him some distance from sows. He should not be used for stud purposes until 8 or 9 months old, and then only sparingly at long intervals—the first season 8 to 10 sows should be the limit, after that up to 40 or 50 sows may be served in the season if he is used judiciously. The boar should be properly penned with ample room for exercise, and provided with shade, shelter, and plenty of clean water. While developing and in season he should be well fed with nitrogenous foods with a reasonable amount of green stuff such as lucerne, peas, vetches and clovers, these being particularly good. When out of service, the ration should be considerably reduced, but the animal should not be allowed to fall away. It is advisable in hot weather or if sluggish to put sows to the boar early in the morning before feeding. If firmly and not harshly treated, viciousness may often be avoided, but in any case it is advisable to cut a boar's tusks—it is a safe policy. On no account should the boar be allowed to run with sows, as it is wasteful, and no record can be kept of farrowing dates

THE BROOD SOW.

As the primary object of selecting brood sows is for the specific purpose of breeding stud stock, porkers or baconers, the matter demands a considerable amount of judgment.

The necessity of using a pure bred boar has been already stressed. In the case of sows, however, for stud breeding purity of blood is equally important, but as the raising of porkers and baconers does not necessarily demand the use of pedigreed sows, but rather those possessing certain special characteristics, a description of these qualifications is given. The brood sow must be sound, healthy, and bred from robust, healthy parents. She should possess an inherent maternal instinct, and natural capacity for producing and rearing large litters, in order that a maximum of profit may result.

To insure these points, the sow should be selected from a large litter, and from family strains known to produce large litters. Her colour type and characteristics should be in close conformity with those of the breed she represents.

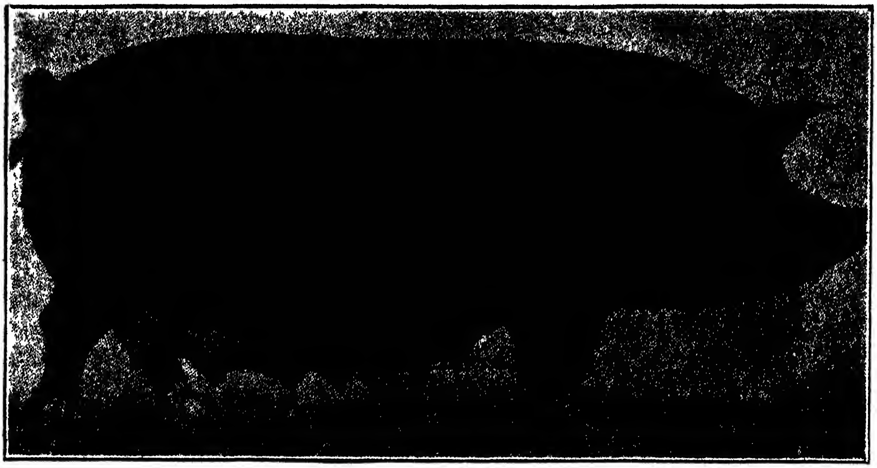


Fig. 11.
A typical brood sow of the Improved Type Berkshire.

In temperament she must be docile and contented, and unselfish when rearing her young. She requires to be of an active, thrifty disposition, with a capacity to consume and assimilate large quantities of food to benefit the embryo young or progeny rather than herself.

Soundness of constitution and robustness are indispensable, and these features should be associated with strong jaws, open nostrils, good width between eyes and ears, sloping shoulders (not coarse or open on top), strong, straight or slightly arched back, freedom from weakness at loins, long barrel, deep sides, well sprung ribs, square rump, good hams, sturdy straight legs squarely set on good feet, smooth mellow hide well covered with soft straight hair, 12 to 14 well placed properly formed teats. Summed up, the essentials are: freedom from coarseness, strength of back and loins, length and depth of sides, good hams, legs and feet, ample evidence of udder development.

MATING.

A *boar* may be put to light work at nine months old, an age at which if properly fed, his virility and masculine character should be sufficiently developed. Judgment, however, is required in mating, the size of both the young gilt or the young boar being a guide as much as the age as to whether it is safe to mate the animals. The male used also should be one that will tend to correct any faults that the female may have, which, however, should be only of a minor manner, otherwise the animals should not be used as breeders.

Well nourished *sows* usually show signs of sexual heat or oestrum when from five to six months old. This condition lasts for three to four days, and recurs every three weeks, until pregnancy occurs. Young sows should not be mated until ten months old, unless unusually well developed for their age. The result from breeding from younger sows, is that their nourishment of the foetus may impose a heavy toll on the vital functions of the mother, her development is limited, and the size and virility of the piglets may suffer.

The normal period of gestation is sixteen weeks (112 days). Under favourable conditions it is possible to rear two litters in twelve months. If permitted the sow will take the boar at the first oestrum period, which occurs three or four days after

farrowing. This exerts too great a strain on the sow, however, and larger, stronger litters are produced where service is delayed until after the piglets are weaned. Under these circumstances it will be realised that the boar should not be allowed to run with the sows, but should be kept in a separate yard, and only allowed with the sows when a service is desired, the date of which can be noted and the date of birth readily calculated.

While it is possible to obtain two litters in twelve months from sows, under practical farming conditions, such an average is seldom obtained. The practice means that pigs must be weaned at eight weeks of age, which is rather young, ten weeks being better, the weaners by this time being able to fend for themselves, and should suffer no "setback" when entirely removed from the sow. No allowance either is made for pigs failing to conceive, which would still further affect the two litters a year programme. Where a farmer owns a number of sows, say five or more, an average of three litters in twenty-four months per sow can be considered satisfactory.

The best returns will be obtained where the pigs are made to fit in with the other operations of the farm, that is farrowing should be regulated so that the weaners are most numerous when the farm feeds are most numerous.

On the dairy farm, weaners should be available to consume the surplus milk when cows are in full profit and pasture growth good. This would be from May to October, necessitating mating from January to June.

On wheat farms, this period would be after the wheat or barley crop has been harvested, about January to March, in which case special provision must be made to compensate for the absence of skim milk and green pasture.

During pregnancy sows must be allowed plenty of exercise, and this can be insured by keeping all breeding sows on the "open air system," that is allowing them the run of a field, the size being immaterial, and if large enough for grazing so much the better. A weather-proof shelter will be required in the winter, but only shade and ample water during the summer months.

THE PREGNANT SOW.

The pregnant sow is called upon to peform a double function—that of nourishing herself as well as the litter of pigs she is carrying. It is therefore imperative that she receive a ration that will supply all material necessary for body building, and plenty of it. Grazing on lucerne or clover pasturage is of great assistance. Sows, however, should not be permitted to get overfat. The effect on the litter is nearly as serious as if the sow becomes emaciated and very thin. The over-fat sow is likely to farrow small litters, and often kills a number of pigs by lying or trampling on them. Often too she has not enough milk and is a poor mother.

The best guide as to whether pregnant sows are being sufficiently fed is the condition of the sow herself; if she is getting too fat, then the ration is too liberal and probably contains too much starchy material, such as maize or wheat grains.

Under dry conditions it may not be possible to provide any green fodder for pregnant sows, and it is necessary to provide those nutrients which normally would be found in such fodder. These nutrients can be supplied in the form of certain animal oils, particularly cod liver oil or oil made from the extracts of other fish, cheap brands of which have been prepared specially for stock and are on the market in Australia. One dessertspoonful of such liver oil per day is recommended to be given to each sow during the times that no green material is available.

BEFORE FARROWING.

About ten to fourteen days before farrowing is due, the sows should be brought in from the paddock and put in a separate pen. It may be necessary to reduce the ration somewhat until after farrowing as the sows will get less exercise than usual while confined to the farrowing pens. The food can be made more laxative, by increasing green material, the use of bran, or by giving 3-4 ozs. of Epsom salts in the slop if considered necessary.

About 8-12 hours before farrowing the sow will exhibit restlessness, and may be seen gathering straw in her mouth and making a nest. It is inadvisable to have a great quantity of bedding available, as the young pigs get underneath this, and are crushed by their mother.

The farrowing pen need not be elaborate—it should be well ventilated, but not draughty, and should have a stout rail all round the inside, about eight inches from the ground. The young pigs are pushed under this when the sow is lying down, and so avoid being crushed.

The young sow should be closely watched at farrowing time, the after-birth removed, and the blood cleaned up, a little slaked lime being spread about. A taste of blood may mean that the sow develops the habit of eating her young, and then must be fattened and slaughtered.

FARROWING CRATES.

Sometimes it is found that certain sows are clumsy during the first few days after farrowing, before the piglets are active, the result being the crushing of the young pigs. It may be undesirable to discard some such sows because of their otherwise excellent characteristics, and in such instances the use of a farrowing crate may be beneficial. The sow is permitted to farrow in these crates, and must be let out for exercise and feed several times during the day, and at such times is away from the young pigs. Because of the extra labour involved, it is doubtful if the use of the farrowing crate will be economical in commercial piggeries, where stout farrowing rails are provided in the farrowing pens.

For the first 24 hours after farrowing, the sow should not receive any food, and after that for the first week the food should be sloppy, laxative and light, a mixture of ground oats and pollard in equal proportions in skim milk being a favourite and satisfactory ration. Plenty of clean water should, however, always be available.

It is inadvisable to lay down the amount of meal to be fed, which will vary with every sow and with every litter. This must be divided by the feeder—as a guide the sow may require 3-4lbs. of meal per day during the first week, increasing to 5-8 lbs. per day at the end of the first month.

During the summer, when no green roughage is available, good meadow hay chaffed, or lucerne chaff that has been soaked for about 12 hours, may be mixed with the meal and fed with satisfactory results. About ½lb. of chaff per day will be sufficient.

There are usually one or two runts in a large litter, and it will be advisable to destroy these when the piglets are a week old; as they will seldom thrive, in comparison with the rest of the litter, and have to be marketed at a later period.

When the young pigs are three weeks old they should be induced to eat by providing a small trough, which is in a pen made of vertical slabs, about 5 to 6 inches apart, which will permit the piglets to pass through, but will exclude the sow. The sow should be fed three times daily.

At four to five weeks old the young males, if not required for breeding, should be castrated.

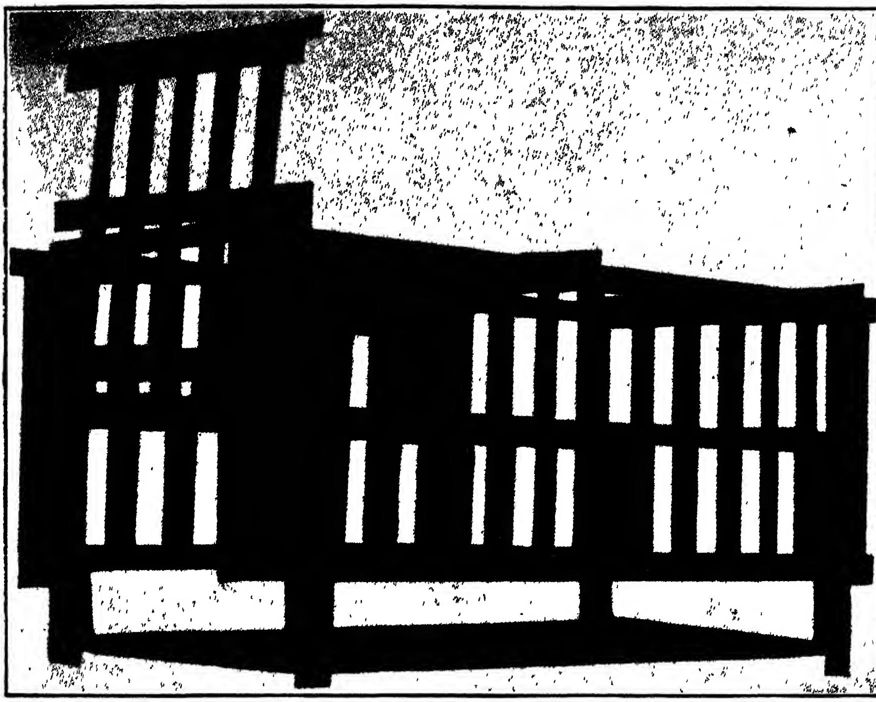


Fig. 12.

A farrowing crate; length 8 ft., width 3 ft., bottom rail 10 in. from floor, with a drop door at either one or each end.

(J. of Agric., Queensland.)

WEANING TIME.

There is a tendency to wean piglets at too young an age—quite commonly weaning is complete by the time piglets are 6 weeks old. This is too young, the pigs generally suffer a check in growth, and take several weeks to recover. Experience has shown that it usually pays to delay weaning until the pigs are 8-10 weeks old, and it will thus be hardly possible to obtain two litters per year.

Weaning should be effected by removing the pigs once and for all from the sow. If they are weaned slowly, by allowing access to the sow at gradually lengthened periods, the young pigs expect the drink, and do not settle down so rapidly as where the change is effected decisively.

The most effective way of weaning pigs is to remove the sow from the litter. This has the advantage that the young pigs are not removed and also subjected to new surroundings.

As soon as the weaner pigs have become used to the absence of the sow, then they may be removed to the field or pen in which they are to remain until about porker weights.

If weaned at 8-10 weeks, it will be found that the sow will seldom be inconvenienced by an accumulation of milk, as occurs if weaned at the age of 6 weeks.

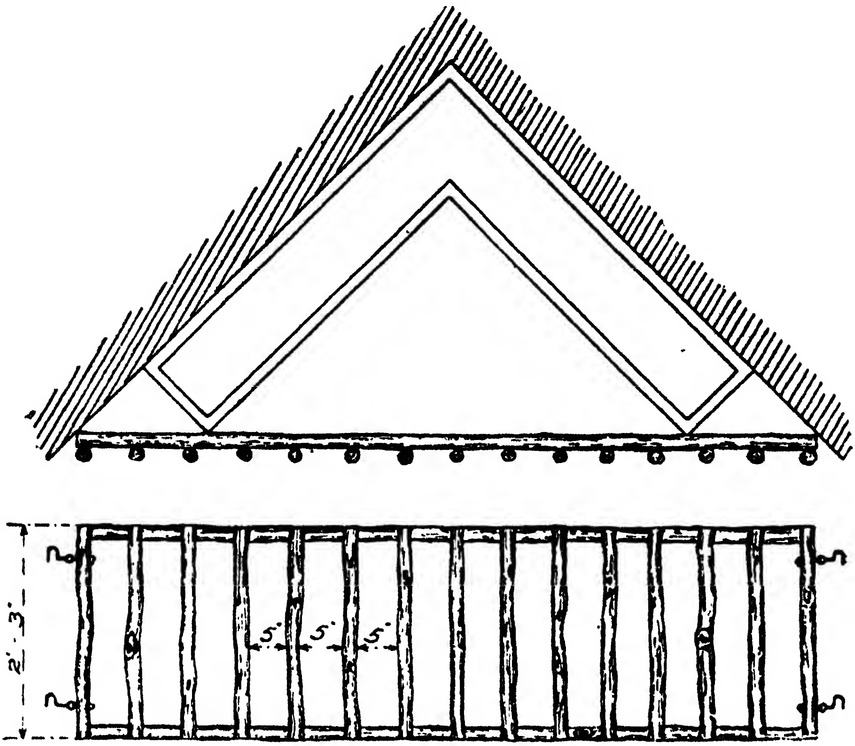


Fig. 13.
Pig Creep used for feeding young pigs prior to weaning.
(Dept. Agric., South Africa.)

FEEDING THE WEANER.

The most satisfactory ration for weaners is one composed of either separated milk or buttermilk, preferably the former, with one of the following grain concentrates:—ground barley, ground wheat or pollard, in the proportion of three parts by weight of milk to one part of meal. Green roughage should also be available.

In the absence of milk a fairly thin slop with water composed of ground wheat 5 parts, pollard 4 parts, meat meal 1 part has given satisfactory results.

The weaners should be fed only what they will clean up in about 10 minutes, and care should be taken to see that the troughs do not become foul or dirty. By the time the pigs are 12-14 weeks old the critical time after weaning is past, and feeding for either pork or bacon production can be commenced.

SEGREGATING ACCORDING TO SIZE.

It is advisable to segregate growing pigs into pens or small fields according to size. This is not so important where pig paddocks are large and self-feeders are being used as where the conditions are such that pigs are being fed in troughs. It is essential, however, to have growing pigs divided into at least *two* classes, namely, those from weaner to porker stage, and those from porker to the finished baconer stage. The reason for this is that pigs should be grown with a full ration

to approximately porker stage, i.e., 90 to 100 lbs. live weight, and thereafter such pigs should be fed a slightly different ration which is not so "forcing" as that used in earlier growth, so as to induce the deposition of lean meat at the same time that fat is being laid on during the latter weeks of feeding. The effect of this is to produce a leaner type of carcase, which, although well filled, has fat and lean intermingled throughout the carcase.

IDENTIFICATION OF PIGS.

It is often convenient on commercial farms and is essential on stud pig farms that some simple method should be available for identifying pigs. Where white pigs are being bred, a tattoo number similar to that which is used for the identification of cattle may be placed in the ear, but no satisfactory ink has yet been found for use with black or red pigs. Tags are often used, but are unsatisfactory, as they tear out very easily. By means of notching the ear, the notch being about half an inch into the ear, an animal can be identified without handling it, and this method is found the most satisfactory.

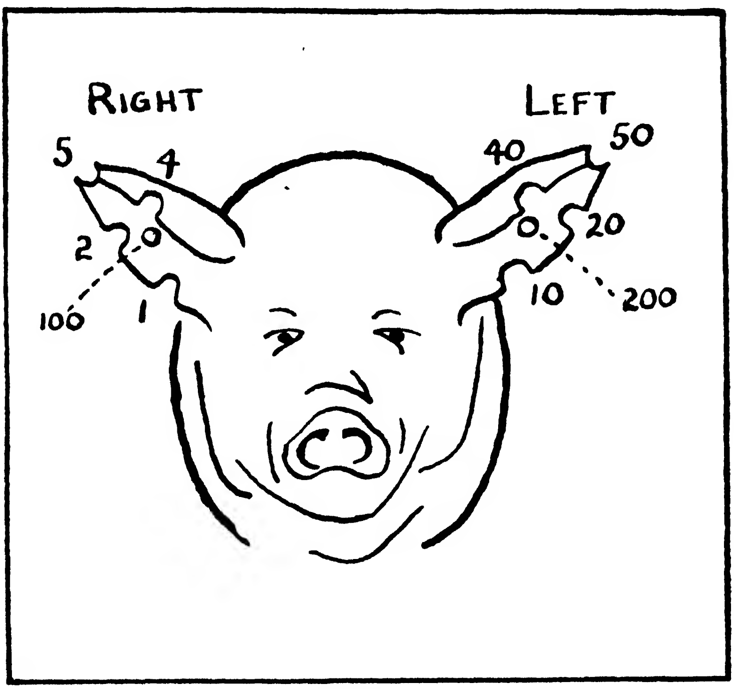


Fig. 14.

No. 3 = notches 1 and 2; No. 9 = notches 5 and 4, etc.

The above diagram illustrates a method which has been in use for several years in the Department of Agriculture and found satisfactory. Numbers up to 399 may be used by this method and, if different shapes are adopted for the holes in the ears, indicating hundreds, this number may be still further increased, but, as a rule, by the time the final number of 399 is reached, all pigs with the earlier used numbers will have been slaughtered or have died, and a start can be made again with number 1.

FEEDING.

In providing rations for any animal, the object in view is to adjust the ration so that it may provide the material and energy required to enable the animal to produce the desired result, which is the production of meat in the case of the pig. In order to achieve this object, it must be remembered that part of the ration is required to maintain the vital functions of the animal, and it is only the excess of the ration over these maintenance requirements (*viz.*, the energy required for breathing, digestion, circulation of the blood, etc.) which can be contributed towards production. In the case of a pig, however, no farmer desires to maintain his pigs at a constant weight, but endeavours to produce an increase in weight of 1 lb. per day at least. If is customary, therefore, to include the foods necessary for maintenance in any ration which is fed without specifically referring to it as such.

In considering foods they can be divided into two main divisions :—

1. Water.
2. Dry matter.

1. *Water.*

The water supply for pigs should be clean. Where this supply is contaminated from decomposing organic matter, as in dams, waterholes, swamps or pools, this water may be a prolific source of diarrhoea, dysentery, worms, and other digestive troubles. A plentiful supply of clean water is of particular importance during the summer months when pigs generally drink water to excess as a means of maintaining an equable temperature in their body.

Experiments at the Illinois Experimental Station have shown that fully grown sows weighing 300 lb. may drink up to three gallons of water per day during hot weather. Much, however, depends on the condition of the animal and the time of the year, but the above will indicate the necessity for an ample supply which should be available always.

In evaluating foods, it is desirable that the groups of substances into which the food can be divided, and the use to which these groups are put in the body of the animal, should be known.

2. *Dry Matter.*

The "dry matter" is the fodder after all moisture has been expelled and includes the mineral matter or ash. This dry matter contains all the nutrients from which energy is developed, wear and tear made good, and new tissues built up. In addition, the dry matter supplies bulk to the ration, which is necessary for digestion to proceed normally.

The dry matter of foods is divided into five groups of nutrients, namely:—

(a) Crude protein or nitrogenous material.
(b) Carbohydrates or starchy material.
(c) Fats, oils, etc.
(d) Fibre, which in the case of the pig may be regarded as indigestible.
(e) Ash or mineral matter.

(a) *Protein.*

The protein is an essential nutrient in the support of animal life, and can only be produced in the animal from foods which contain nitrogenous material. Its special use is to produce blood, milk, lean meat, muscles, tendons, nerves, skin, hair, hoofs, and the gelatinous parts of bones, etc.

Remembering that the pig is one of the fastest growing farm animals and lays on meat more rapidly than other stock, the question of the supply of suitable protein or nitrogenous material in the rations is of paramount importance.

(b) *Carbohydrates.*

These substances which contain no nitrogen are the primary source of heat and energy and are associated with foods containing starch, sugar, fibre, etc. In addition to providing heat and energy, they also may be used for laying on fat. They form the bulkiest parts of all foods and are usually comparatively cheap to purchase.

The pig possesses the power to a markedly high degree of converting these carbohydrates into fat in contrast with other farm animals. For this reason, where the public taste now is for lean bacon and pork, and also in Western Australia where the temperature is comparatively high, care should be taken not to increase the carbohydrates in the food beyond the amount required for health.

(c) *Fats and Oils.*

Fats and oils in foods are also energy and heat producers, and, in the case of the pig, exert an influence on the firmness, appearance, and composition of the fatty flesh. Generally speaking, foods containing large quantities of fat or oil such as linseed meal, cocoanut cake, and cotton seed meal, produce a soft fat in the carcase which is undesirable. Fat will provide about 2½ times as much heat per lb. as the carbohydrates, and its quantity, therefore, should be kept as low as possible in the ration.

(d) *Fibre.*

A certain amount of fibre is necessary in all rations, but, as the stomach of the pig is small, the quantity should be limited to approximately 10 per cent. in the case of young pigs, and below this in the case of pigs which have been weaned recently.

Fibre is best supplied in the form of green feed, though, during the summer months in Western Australia, it may be necessary to feed chaffed meadow hay or immature oaten or wheaten chaff in order to provide this roughage.

(e) *Ash or Mineral Matter.*

It is essential that adequate supplies of mineral matter should be available for the growing pig. The minerals which are usually lacking are lime, phosphorus, and chlorine, which, if required, could be provided in the form of bonemeal, slaked lime, di-calcic phosphate, or salt.

As the rations of pigs usually contain a large proportion of grain, which is high in phosphoric acid, lime is usually the element which is lacking.

It is not sufficient, however, to know the chemical composition of foods, which supplies information regarding the relative quantities of each of the five groups of nutrients mentioned above, because the whole of these substances are not available to the animal but only those portions which are digested.

Further, some foods are particularly difficult to digest, and the energy expended in digestion also must be deducted from the food in order to arrive at its true value. A ration containing a high percentage of chaffed wheat straw may

be definitely detrimental, as the pig would be unable to digest this roughage, whereas such a ration fed to a ruminant might supply some energy towards the maintenance after the cost of digestion has been deducted.

A considerable amount of work has been carried out by experimental stations in America and Great Britain to discover the net value of various fodders for different types of stock, and these figures are usually those which are utilised in comparing the value of different foods.

The following Table 1 sets out the percentage of digestible nutrients in those foods which probably would be available in Western Australia, and also supplies information regarding the percentage of protein to non-protein matter in each food. This percentage figure is called the nutritive ratio.

TABLE 1.

FOODS SUITABLE FOR PIGS.

Digestible Nutrients in 100lbs. Dry Matter.

Foodstuff.	Dry Matter.	Crude Protein.	Starch Equivalent.	Nutritive Ratio, 1 :	Effect on Bacon.
Cereal Grains—	%	%	%		
Barley	88	9.3	85	8.4	Very Good.
Maize	87	8.4	94	10.3	Excellent.
Oats	88	8.0	71	8.3	Good.
Wheat	88	10.2	83	7.5	do.
Leguminous Grains—					
Peas—Field	88	22.0	84	2.9	do.
Lupins	86	27.4	75	2.1	
Concentrates—					
Bran	88	14.6	54	3.6	do.
Linseed Meal	88	22.1	129	5.0	With care.
Meat Meal	92	65.0	100	0.62	Good.
Pollard	88	15.5	80	5.6	do.
Skim Milk ... ... } Butter Milk ... ... }	10	36.0	91	1.5	do.
Green Fodders—					
Lucerne:					
Bud	20	19.0	52	2.4	
Full Flower ...	25	14.0	42	3.0	
Maize	22	5.0	57	13.0	
Rape	14	17.8	58	2.9	
Subterranean Clover:					
Young	18	19.0	68	2.9	
Hay	25	10.8	44	4.4	
Mature	90	4.5	30	10.0	
Potatoes	21	1.1	18	16.0	

The compounding of rations for pigs is a comparatively simple matter, if it is remembered that the stomach of the pig is small and that substances which would be extremely bulky in order to supply the nutrients required are unsuitable for feeding to pigs.

As a guide, the quantity of grain consumed by a pig is approximately 1 lb. per day for each month of age of the pig, in addition to an ample supply of water. If this weight of food is supplied, then all that is necessary to do is to ensure that the proportion of protein to carbohydrates should be correct.

The following table sets out the nutritive ratio required in rations for pigs of varying weights, which will enable suitable feeds to be supplied:—

TABLE 2.

NUTRITIVE RATIOS FOR PIGS OF VARYING WEIGHTS.

		Protein.		Carbohydrates.
Sows with litters require feed balanced	... ...	1	to	3.5
Pigs 40 to 100 lbs.	fattening	1	"	3.5 to 4.0
100 " 150 "	fattening	1	"	4.5
150 " 200 "	fattening	1	"	5.0
up to 200 " 300 "	fattening	1	"	6.5
Boars 300 " 500 "	... ...	1	"	5.5 to 6.5
Sows (pregnant) 200 to 350 lbs. ...	... ...	1	"	5.5
Sows (gilts) 150 " 300 " ...	... ...	1	"	5.0

The following example in calculating a ration to feed six pigs weighing from 100 to 150 lb. each will indicate the use of Tables 1 and 2 above in compounding rations:—

From Table 2 it will be noted that such pigs require a nutritive ratio of 1 : 4.5. The foods which are available are wheat, pollard and skim milk. By referring to Table 1 the compositions of these foods can be ascertained, the calculation then being as follows:—

	*Protein.	†Non-Protein Nutrients.	
100 lbs. wheat	9.0	67.5	
50 " pollard	6.9	38.6	
300 " skim milk	10.8	16.2	
	26.7	122.3	= 1 to 4.6

From Table 1—

* 100 lbs. wheat contains 88 lbs. dry matter; 88 lbs. dry matter contains 10.2 × $\frac{88}{100}$ digestible crude protein = 8·97 (approx. 9.0).

† Non-protein nutrients = digestible crude protein × nutritive ratio.

Another Example—

	Protein.	Non-Protein. Nutrients.	
75 lbs. maize	5.5	56.6	
50 " pollard	6.9	38.6	
375 " skim Milk	13.5	20.2	
	25.9	115.4	= 1 to 4.5

Either of the above rations, therefore, would be suitable for feeding to pigs weighing 100 to 150 lbs. live weight.

Quantity of Feed.

Although usually pigs are fed an amount of ration which they will "clean up" in from 10 to 15 minutes, or, in some cases, are fed through a self-feeder, it is desirable that the farmer should be able to estimate the quantity of any ration which pigs of various weights should receive.

As the various concentrates usually fed are mixed in certain proportions so as to give a nutritive ratio suitable for the type of pigs being fed, it is only necessary for the correct amount of protein to be fed in order to ensure that the pigs are receiving all they require. This amplifies the feeding of pigs considerably in comparison with dairy cows.

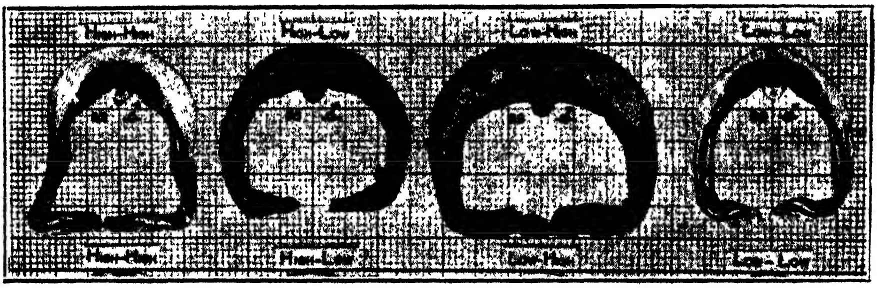


Fig. 15.

The effect of four methods of feeding, as shown by cut through chest cavity:—High-high: Pig force fed from birth to bacon weight, overfat, and side short, wasteful flap in belly. High-low: Pig force fed to porker stage, and then growth slowed down till bacon weight of 200 lbs. live weight, well balanced lengthy carcase, meat and fat in right proportion, good streak. Low-high: Pig kept in good store condition to porker weight and then "topped off" rapidly by forcing ration, too fat, small development of lean meat, wasteful belly. Low-low: Pig fed so as to maintain good store condition till bacon weight of 200 lbs., slow development, too much lean.

[J. of Ministry of Agric., England.]

The following table sets out the daily quantities of protein which should be fed to pigs of varying weights, and, knowing this figure, it is a simple matter to calculate the pounds of any particular ration required to supply this amount of protein.

PROTEIN REQUIREMENTS OF PIGS.

Live Weight. lbs.	Digestible Protein. lbs. per day.
50	0.30
100	0.50
150	0.56
200	0.61
250	0.66
300	0.69

GENERAL CONSIDERATIONS.

Grinding or Soaking Grain.

Whether the grinding of grain for pigs is profitable is a matter of great economic importance, and the result of experiments now enables definite information to be given. With a large grain such as maize, it is immaterial whether or not the grain is ground, as it is so large that pigs are unable to swallow it without crushing the grain. With small grain, however, such as wheat, barley, oats, and peas, much of the grain passes through the animal undigested, and grinding or crushing is definitely desirable. The smaller the grain the greater the amount undigested, the saving effected by grinding varying from 8 per cent. to as much as 22 per cent. according to the grain used.

Regarding the soaking of small grain, experiments indicate that the soaking of the foods is unnecessary, and it is because of this that self-feeding becomes economically possible. In cold countries pigs are often fed their ration in the form of slops as a means of inducing them to consume greater quantities of water, but, in a climate such as Western Australia, this is unnecessary.

Cooked Foods.

Early agriculturists strongly advocated the cooking of food for pigs, but numerous experiments have shown conclusively that, instead of a gain from cooking, there is in nearly every case a loss. In twenty-six trials in America, using corn, barley, rye, peas, either separately or in combination, it was found that there was a loss of approximately 10 per cent. in digestibility through cooking. The only common food in this State which benefits from cooking is the potato.

Limited Feeding versus Full Feeding.

One of the most important questions that every pig-raiser has to decide is how much grain he will feed his fattening pigs. It is known that the larger the amount of grain fed, the faster will be the gain in weight, whether the pigs be running on pasture or are sty fed, but there is some doubt whether there would not be more profit if sometimes the amount of concentrates fed were restricted. This is particularly so, as the market demand is for a relatively lean type of carcase.

Several considerations affect the economy of the practice of full feeding. At certain times of the year the prices for pig products are higher than the average, such as during December for the Christmas market, and there is generally a shortage of pigs from March to June, and it may pay to full-feed in order to hasten maturity, so as to obtain the benefits of this higher market.

Experiments conducted in Great Britain and also at Mr. W. G. Burges's farm, "Tipperary," York, last year indicate, however, that full feeding may not only be unprofitable at certain times of the year, but tends to produce an over-fat carcase which is not desired by the trade. In the experiments at York, however, rather than restrict the bulk of ration being fed, the quantity of roughage in the ration was increased, although there is apparently no benefit through increasing this roughage beyond 10 per cent. The roughage utilised should be first quality meadow hay or cereal chaff.

The result of this practice is to delay the period of maturity, but tends to produce a lengthy and leaner type of carcase.

Home-grown Foods.

From the previous discussion dealing with meal mixtures and purchased concentrates, it may be inferred that these fodders constitute the main foods for market pigs. A feeder may be able to produce excellent market pigs and yet, at the prevailing price the result of his operations may be a definite loss. Profits from pigs, as with other types of animal production on the farm, are largely controlled by the ability of the feeder to make the best use of the foods which he finds to hand, or that he can produce on the farm at a low cost. It may be necessary to supplement these home-grown fodders by the purchase of certain concentrates, but the more these former fodders are consumed in proportion to purchased foods the greater will be the ultimate profits.

Grains.

Wheat.—In Western Australia the principal grain which will be used as a basis for pig-feeding is undoubtedly wheat. Wheat alone, however, is not a complete ration for growing pigs, being low in protein for flesh-building and also lacking in mineral matter for skeleton formation. This grain should predominate in the ration of pigs fed in dry areas, and it has been shown to be possible to produce a good market pig on nothing but crushed wheat, milk or meatmeal and the necessary mineral requirements. While such a limited ration is by no means recommended, it tends to show the possibilities of this grain.

Barley.—Barley is a grain which can be grown in the South-West portion of the State and is the equal of wheat for the production of high quality pork or bacon. As with wheat, however, suitable supplements are required.

Oats.—In the Dominion of Canada, oats is regarded as the best single grain for market pigs and is said to have a peculiar value in the development of a long and lean carcase. The quality of oats, however, grown in Western Australia is not suitable for forming the bulk of the finishing ration, as pigs do not fill out on this grain but tend to keep in store condition. When feeding oats, quality is essential. Light, shrunken, poorly filled grain is of little value.

Peas.—This grain can be grown to advantage throughout the dairying districts of the State and is excellent as forming part of a "topping off" ration—either fed ground or by permitting the pigs to harvest the grain from the field. The quality of bacon from pigs fed on peas is excellent.

Fig 16.

Sows grazing on good mixed pasture need little other feeding until near farrowing time.

Pasture and Green Feeds.

Pasture undoubtedly may be put to good use on the average farm. During the winter months when pasture growth is at its best, little else is rquired for growing pigs.

Where pasturing is employed, lucerne and clover are the best crops. Oats or barley, if fed when six inches high, give excellent results. Rape is another useful crop and is best suited for pigs from the porker to the bacon stage.

In every instance where pasture is available, pigs will thrive better if some skim milk is available also.

For brood sows and young breeding stock, pasture provides not only the cheapest but the most healthful method of feeding For pregnant sows, such outdoor conditions prove ideal and little else would be required.

Roughages and Succulent Foods.

During the summer months it is impossible on the average farm—unless irrigation is available—to provide green fodder crops for pigs. Experiments have shown that lucerne hay, subterranean clover hay, or early-cut meadow hay are very valuable foods for the brood sow in particular, but also for the market pigs. Such hay should be fed in racks from which the pigs will procure the roughage as required.

Pigs require fibre and will get it in some form or other if only through eating straw or bark of trees. Comparatively little is eaten per head—not more than about ½ lb. per day—and there is ample evidence to the effect that it promotes thrift and health in the pigs.

Milk Products.

As a class, these form the most valuable of all pig foods either purchased or home grown. Experience in Canada has shown that, where no milk at all is available and weaners are abruptly removed from the mother to a milkless ration, a low percentage of selected grade hogs usually results. Even a small quantity of milk, however, seems to supply the nutrients that are lacking, and it should be seldom in Western Australia that milk would be entirely impossible to obtain. Meatmeal practically can replace skim milk in the ration. Skim milk and butter milk generally are classed as of equal value.

In evaluating skim milk, 5 lb. of skim milk is equal to 1 lb. of grain in feeding value. Whey may be regarded as of about half the value of skim milk. It is not as valuable as skim milk for young pigs, but fulfils the function of skim milk in pigs of the porker and bacon stage

The farmer with a home-produced milk by-product at his disposal has the cheapest, safest, most productive, most palatable and surest feed available, and the one item of diet that should ensure the quality and type of the finished baconer.

Foods that may be Purchased.

It may not always be possible to feed pigs entirely on home-grown foods. In fact, the greatest returns are seldom obtained by this practice. In Western Australia the purchased grains will be by-products of wheat, barley, or oats. Bran is the most valuable and widely-used wheat by-product for stock generally. It is palatable and peculiarly useful on account of its laxative qualities, and, for this reason, forms a standard food for the brood sow during the fortnight before farrowing when she is usually hand fed. Pollard, however, is more suitable for feeding to fattening pigs and has not the laxative effect of bran, the feeding value of the two being approximately the same.

Slaughter House By-Products.

On wheat belt areas where skim milk is available only in limited quantities, meatmeal must be purchased as a high protein supplement to the grain ration. It is essential to feed such a supplement in order to reduce the protein ratio of wheat, which is 7.5, to about 4.5, which is that required by growing pigs. The protein ratio of meatmeal is about 1 : 0.62, and for some time this food

has been the cheapest form of protein on the West Australian market. This supplement is useful in the ration of pigs of all ages, and, even although not required, is sometimes added in small quantities as a relish to the ration. It is a useful supplement to the ration of the brood sow, as it gives strength to the piglets in utero and is an insurance against the habit of devouring the newly-born litter. Usually about 5 to 10 per cent. of the meal ration may be made up of meatmeal, the proportion depending on the age of the pigs being fed. (See Table 2.)

Mineral Supplements.

Owing to the rapidity of its growth, no domestic animal shows the results of mineral deficiency so rapidly as the pig. There is a heavy call on bone-building constituents, particularly calcium and phosphorus. This deficiency is likely to occur very quickly where pigs are sty fed and have not access to earth. Where lucerne or clover grazing is available, or these crops are fed as good quality hay, there is not likely to be a deficiency of either of these minerals. Charcoal is relished by pigs and has absorbent and digestive qualities which keep the organs in a healthy condition. From time to time also, particularly with sty fed pigs, a little salt should be included in the ration.

Where meatmeal is being fed, there is not likely to be a deficiency of phosphorus, but as the other portion of the ration will be mainly wheat or a similar grain, there may be a deficiency of lime, which can be supplied by an addition of 1 to 2 per cent. of ground limestone or bonemeal to the ration.

RELATIVE FOOD VALUES OF CONCENTRATES.

PERTH, DECEMBER, 1936.

Foodstuff.	Cost.	Cost per 100 lb.	Starch Equivalent per 100 lb.	Digestible Protein per 100 lb.	Cost per 1 lb. Starch Equivalent.	Cost per 1 lb. Digestible Protein.
		s. d.	lb.	lb.	d.	d.
Wheat	5s. 6d. per bushel of 60 lb.	9 2	83	10.2	1.33	10.78
Oats	3s. 2d. per bushel of 40 lb.	7 11	71	8.0	1.34	11.88
Bran	£7 10s. per ton ...	7 6	54	14.6	1.67	6.16
Pollard	£7 10s. per ton ...	7 6	80	15.5	1.12	5.81
Linseed Meal ...	£12 10s. per ton ...	12 6	80	29.0	1.88	5.17
Meat Meal (W.A.)	13s. per 100 lb. ...	13 0	100	65.0	1.56	2.40
Peas	Unobtainable ...	...	...	...	...	...
Young Subterranean Clover Pasture *	20s. per ton ...	1 0	65	19.0	0.19	0.63
Subterranean Clover Silage	10s. per ton ...	0 6	43	9.4	0.14	0.64

* Dry matter.

The above table shows that for the supply of energy or fat-forming foods, among the grains, wheat, oats and pollard are approximately the same value, pollard being slightly cheaper than the other two.

The cheapest source of protein or flesh-forming food, apart from pasture and silage, is meatmeal. Protein in meatmeal is approximately half the cost of that contained in linseed meal.

No purchased concentrate, however, can compete with young clover pasture or clover silage in economy of production.

FEEDING PIGS IN THE WHEAT BELT.

The basic foods which will be available in dry areas are wheat, barley, and oats, depending on the district in which pigs have to be fed. Probably no single fact in stock feeding has been more clearly demonstrated by numerous feeding trials than that maize, wheat, and other cereal grains alone give exceedingly poor results when fed to growing and fattening pigs.

The following table summarises the results of seven trials in which maize alone was fed to young pigs, averaging 69 lb. in weight, in comparison with another group of pigs where meatmeal was added to the maize ration. The results also are given for 15 similar comparisons of *maize alone versus maize and meatmeal* for older pigs averaging 184 lbs. in weight when the experiment began.

TABLE 3.

MAIZE ALONE *VERSUS* MAIZE AND MEATMEAL.

Average Ration.	Length of Trial.	Daily Gain.	Feed for 100 lbs. Gain. Maize.	Feed for 100 lbs. Gain. Meatmeal.
With Young Pigs—	days.	lbs.	lbs.	lbs.
(1) Maize alone, 3.5 lbs.	122	0.59	642	...
(2) Maize, 4.4 lbs. ... ... Meatmeal, 0.48 lbs.	122	1.18	387	42
With Older Pigs—				
(1) Maize alone, 5.7 lbs.	69	1.03	617	...
(2) Maize, 6.1 lbs. ... ... Meatmeal, 0.67 lbs.	66	1.59	400	43

It will be seen that the younger pigs gained only 0.59 lb. per head daily and required 642 lb. maize for each 100 lb. gain. Where meatmeal was added the gains were practically double, and only 387 lb. maize were consumed for each 100 lb. gain.

Similar results were obtained with the older pigs, although, as might be expected, this group did not show the effect of the omission of the meatmeal so seriously as in the younger pigs.

In numerous experiments where wheat and maize have been fed in comparison, it has been shown that their value is similar, wheat being slightly superior.

From the above, the folly of feeding such an unbalanced ration as maize or wheat alone will be realised, and yet there is ample evidence at various sales that pigs are being fed on such a ration, which makes the carcases short, stumpy, and very fat.

Some roughage also is necessary which, in the winter time, can be supplied by grazing, and, in the summer time, from the use of good cereal chaff or meadow hay, mixing about 10 per cent. with the grain ration.

Shrunken wheat that has been injured by drought or frost before maturity can be economically fed to pigs, although it may be unsuited for milling and would realise a low price. Such wheat is usually richer in protein than wheat of good milling quality, and, if not excessively immature before the check in growth occurs, may be equal in feeding value to sound wheat.

Inquiry is sometimes received regarding the value of pickled wheat for feeding to pigs. This depends on the chemical used for pickling. In the case of Formalin, the wheat should not be fed to stock. In the case of Copper Carbonate, provided the wheat has been thoroughly soaked in two changes of water, there will be little danger from feeding to pigs, as the Carbonate is dissolved in the water.

Wheat or other grains always should be ground or crushed before feeding, the saving in the case of wheat being from 16 per cent. to 22 per cent. Soaking wheat is a poor substitute for grinding, as it makes little saving over feeding the grain dry.

Barley may be regarded as approximately the same value as wheat for feeding to pigs and should be treated in a similar manner.

Good feed oats, when used to replace barley or wheat, should be regarded as worth about three-fourths the value of these two grains.

In feeding trials in America and Great Britain, it has been found that approximately 4.4 lb. of wheat is required to produce 1 lb. of bacon. Feeding trials in Queensland and at "Tipperary," York, Western Australia, have shown that a lesser quantity than this is required, namely, from 3.6 to 3.9 lbs. to produce 1 lb. of bacon. This is due probably to the warmer climatic conditions which would reduce the food required for maintenance as compared with that in colder countries.

The following ration is one that has given good results and is recommended for use in wheat producing areas:—

Crushed Wheat or Barley	80 parts.
Meatmeal—60 per cent. Protein	9 „
Good Oaten Chaff	10 „
Ground Limestone	1 „

Pigs should be fed as much of the above ration as they will "clean up" in about 10 to 15 minutes twice per day, which, under ordinary circumstances, will be found to approximate 1 lb. per day for each month of age of the pig.

In dry areas it is essential that ample shade and water should be available always. It is not necessary to erect expensive shelters, a cheap shelter, being that illustrated, may be made of posts and wire netting about four feet from the ground on which 9 to 12 inches of straw has been placed. This may be destroyed at the end of the season if thought fit.

Fig. 17.

Cheap shelter suitable for wheat belt conditions. Water troughs also could be covered in this manner.

PORK OR BACON.

The most profitable period for the feeding of pigs is from the time they are about 80 lb. live weight up to bacon stage, i.e., about 170 lb. live weight.

In order that pork production should be profitable, it is necessary that a higher price per lb. should be received for this carcase. The difference between pork and bacon prices—in order for pork to be profitable—will vary with the price of grain. As a guide: With wheat at 3s. per bushel, pork should be 1½d. per lb. more than bacon to be profitable. With wheat at 3s. 6d. per bushel, pork should be 1¼d. more. With wheat at 4s. per bushel, pork should be at least 1d. per lb. more.

It is only for short periods each year on the local market that these differential prices obtain. During 1934-35 this profitable difference in favour of pork only existed during nine weeks of the 52, and six of these weeks were immediately prior to Christmas.

Generally speaking, farmers situated any distance from the metropolitan area would be well advised to aim at bacon production rather than pork.

VALUE OF WHEAT FOR BACON PRODUCTION.

The following table shows the value of wheat at varying prices when used for feeding pigs. The ration used as a basis of the calculation is that recommended above.

TABLE 4.

EFFECT OF BACON PRICES ON VALUE OF WHEAT FOR FATTENING PIGS.

Bacon Prices, per lb.	Value of Carcase, 120 lbs.	Net Return after deducting Cost all Feeds except Wheat.	Value of Wheat per bush.
s. d.	s. d.	s. d.	s. d.
0 7	70 0	60 4	7 6½
0 6½	65 0	55 4	6 11
0 6	60 0	50 4	6 3½
0 5½	55 0	45 4	5 8
0 5	50 0	40 4	5 0½
0 4½	45 0	35 4	4 5
0 4	40 0	30 4	3 9½

Feeding trials in South Australia during 1939 with barley as the grain concentrate and fed with meatmeal confirmed the above values first published in 1936.

FEEDING PIGS IN THE DAIRYING DISTRICTS.

The by-products on dairy farms, which are difficult to utilise unless fed to pigs, will consist of skim milk and—where farmers are close to factories—butter milk and whey. These products are specially valuable by reason of the character of the protein which they contain and also its high digestibility, which is practically 100 per cent. These products are also rich in mineral matter, especially in lime and phosphorus, which are the chief minerals forming the skeleton.

It has been claimed that fat soluble vitamin has been removed from skim milk, butter milk and whey, and for this reason, if any of these by-products are fed with a grain low in this vitamin, such as white maize, it may result in poor returns. This deficiency, however, is cheaply supplied by making lucerne or clover available to the pigs either in the form of grazing or as hay.

Fig. 18.

A crop of maize grown for grain, the pigs being allowed to harvest the grain from the cobs themselves. An economical method of feeding grain with skim milk.

In arriving at a feeding value for skim milk, this food should be compared with the most efficient commercial substitute, which is meatmeal. No progressive farmer would attempt to feed pigs on such an inefficient ration as grain alone when they are not on clover pasture.

The following table shows the comparative value of skim milk and meatmeal as a supplement to maize for fattening pigs, and, as mentioned before, wheat or barley is comparable to maize, but slightly superior for this purpose.

TABLE 5.

SKIM MILK *VERSUS* MEATMEAL AS A SUPPLEMENT TO MAIZE.

Average Ration.	Daily Gain	Feed for 100 lbs. Gain.		
		Maize.	Skim Milk.	Meatmeal.
	lbs.	lbs.	lbs.	lbs.
(1) Skim milk, 7.1 lbs. Maize, 4.6 lbs.	1.36	346	535	...
(2) Meatmeat, 0.47 lbs. Maize, 4.90 lbs.	1.24	404	...	39

These trials, which are the average of 12, show that skim milk is slightly superior to meatmeal for supplementing grain.

For feeding to young pigs before and soon after weaning, skim milk is best if fed fresh, although even for young pigs, as long as souring is effected under sanitary conditions, results are satisfactory. If, however, sour milk must be used, it always should be fed sour. Feeding sweet milk at one period and sour at the next is apt to cause scours.

MONEY VALUE OF SKIM MILK.

Feeding trials have shown that 100 lb. of skim milk can replace in the ration approximately 11 lb. of wheat and 7.25 lb. of meatmeal, and its money value, therefore, with wheat and meatmeal at various prices, may be readily computed. Butter milk also may be regarded as equal in feeding value to skim milk.

In considering these values, however, it should be borne in mind that they are only true when no more milk is fed than is needed to balance the ration. If greater quantities of skim milk are provided than necessary for this purpose, the extra amount consumed is converted into fat and not into lean meat, the nitrogenous portion being lost in the excreta. It is, therefore, uneconomic to feed skim milk or butter milk alone.

TABLE 6.

MONEY VALUE OF SKIM MILK OR BUTTER MILK PER GALLON FOR PIGS.

Value of 1 gallon skim milk or butter milk—	Price of Wheat per Bushel. 3s. 0d.	3s. 6d.	4s. 0d.	4s. 6d.	5s. 0d.	5s. 6d.
	d.	d.	d.	d.	d.	d.
With meatmeal at £12 per short ton	1.70	1.81	1.92	2.03	2.14	2.25
„ „ „ £13 „ „ „	1.79	1.90	2.01	2.12	2.23	2.34
„ „ „ £14 „ „ „	1.88	1.99	2.10	2.21	2.32	2.43
„ „ „ £15 „ „ „	1.96	2.07	2.18	2.29	2.40	2.51
„ „ „ £16 „ „ „	2.05	2.16	2.27	2.38	2.49	2.60
„ „ „ £17 „ „ „	2.14	2.25	2.36	2.47	2.58	2.69

Meatmeal, £14 per ton; oaten chaff, £3 per ton on farm.

When the supply of skim milk is low, it is not necessary to feed more than 3 to 4 lb. for every 1 lb. of grain consumed, but, under average conditions, from 6 to 10 lb. of skim milk for every 1 lb. of grain will give satisfactory results, the greater quantity of milk being used when feeding the younger pigs.

WHEY.

Whey is relatively low in protein, as the casein of the milk is removed in cheese-making. Because of this, its nutritive ratio is 1 : 6.8 in comparison with 1 : 1.5 in the case of skim milk. Owing to this low content of protein whey is sometimes overlooked as a supplement to cereal grains.

Feeding trials, however, have shown that whey is of considerable value when fed with certain grains for fattening pigs. When fed with barley, surprising results have been obtained where about 3 lb. of whey per lb. of barley forms the ration, gains of as much as 2.2 lb. per day being obtained. This was in spite of the fact that the ration had a nutritive ratio of 1 : 7.4. These results apparently are due to the fact that, while whey is low in protein, what it does contain—which is chiefly milk albumin—is of excellent quality to serve as a supplement to the proteins of cereals.

These pigs were approximately 125 lb. live weight when feeding commenced. With younger pigs it is found necessary to add some protein rich food, such as meatmeal, or linseed meal, in order to balance the ration. About 1 lb. of meatmeal or 3 lb. of linseed meal should be added to the ration for every 10 gallons of whey.

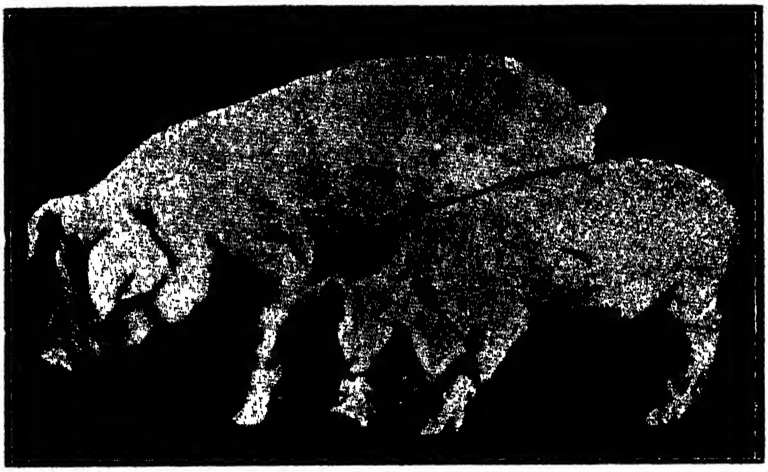


Fig. 19.

Skim Milk made the Difference.

These two pigs are of the same age, from the same litter, were both weaned from mother at six weeks old, and were both fed as much ground oats, ground barley, and ground corn as they would eat. They were kept in the same feed barns and were cared for by the same persons, the only difference being that the larger one received milk and the smaller one had no milk. The pig receiving no milk is not only smaller but he has a poor coat, has scurvy, and is in every way a poor specimen.

SUPPLEMENTS TO SKIM MILK IN DAIRYING DISTRICTS.

In these districts one of the greatest advantages over the dry areas is the ability to supply good grazing or green fodder crops during the greater portion of the year. Where lucerne or clover can be supplied in the form of grazing, about 4 to 5 inches high, little else is required beyond skim milk in order to ensure rapid growth until about one month from bacon weight. Such pigs, however, if forwarded to the market without being "topped off" with some grain, do not dress out economically, and the quality of the fat is inferior. The pigs are described in the trade as being "soft." In order to overcome this, it is essential that grain in one form or another should be supplied. It is not necessary to confine the pigs to sties in order to do this, as the grain may be fed either by hand twice a day—usually at the same time as the skim milk—or self-feeders may be placed in the paddocks where the pigs to be "topped off" are grazing. It is uneconomical to self-feed the growing pigs or sows, so that several small pig paddocks are required for efficient management.

In order to obtain the best returns, an effort should be made to provide the grain from home-grown produce. Barley or peas can be grown successfully, and it should be possible in many areas for either maize or a mixture of maize and cow peas to be grown and allowed to ripen, so that pigs may be

"topped off" in the field (see Fig. 18). Where peas are being grown, as the nutritive ratio of peas is 1 : 2.6, it is uneconomical to feed alone or to graze peas. It generally will be found profitable to purchase wheat, barley, or pollard to be fed in conjunction with the peas, equal quantities of either with peas forming the ration with skim milk as before.

At certain times of the year potatoes may be available and would be suitable for feeding with peas, as potatoes are very low in protein, their ratio being wide, 1 : 11.

Four to 5 lb. of potatoes are the equivalent of 1 lb. of grain.

A mixture such as maize and cow peas, if sown early in the summer, should ripen within 4 to 5 months and may then be harvested by the pigs themselves, from which a complete ration could be obtained.

The importance of grazing in conjunction with feeding in the dairying districts, however, should not be overlooked, as the saving in grain, where good grazing is available, varies from 10 to 15 per cent., and the supply of grain is the expensive portion of the ration in these districts.

Fig. 20.
Cow Peas and Maize, S. F. Russell, "Wendowie," Serpentine.

SELF-FEEDING.

There is now no doubt that permitting pigs to feed themselves from supplies of rations, either separately or ready mixed, is not only economical but ensures a great saving in labour. The system of self-feeding gives excellent results with *growing fattening* pigs, or with old sows which are to be fattened.

The self-feeder should not be used when rapid gains are not required, or for growing pigs for the breeding herd, or for pregnant sows, unless some bulky food such as clover chaff or good oaten chaff is mixed with the grain. For such pigs, however, hand-feeding would be preferable.

The following table shows the results of 17 trials of hand-feeding pigs in comparison with self-feeding. It will be seen that the self-fed pigs grow a little more rapidly than the hand-fed pigs and consume rather less of the ration for each 100 lb. gain in weight. In these trials the pigs had no pasture available, but similar results were obtained in other trials where pasture was available.

TABLE 7.

SELF-FEEDING *VERSUS* HAND-FEEDING.

Without Pasture. 314 Pigs—Average weight, 86 lbs.

	Daily Gain.	Feed for 100 lbs. Gain.		
		Maize.	Meatmeal.	Total.
	lbs.	lbs.	lbs.	lbs.
(1) Self-Fed	1.58	359	56	415
(2) Hand-Fed, twice per day all that they would clean up	1.42	356	68	424

Similar results were obtained where pasture was available.

It is immaterial whether the ration be mixed and all fed through the one self-feeder, or whether a number of self-feeders are used, each containing a separate ingredient of the ration. The pigs apparently will eat the various proportions as required in order to give maximum growth. It is usual, however, to mix the ration where more than one grain is being used, and also the meatmeal may be mixed with the grain ration without any physical inconvenience in feeding.

Fig. 21.
The Self-Feeder working.

It is necessary to inspect the feeder at frequent intervals to see that the troughs are clean and that a free flow of food is available from the hopper. The feeder should be located on a dry area of land and, if possible, mounted on skids so that it can be removed to a clean place when necessary.

The following are details of a self-feeder which has given excellent results in Canada and Australia and is suitable for feeding from 15 to 20 pigs.

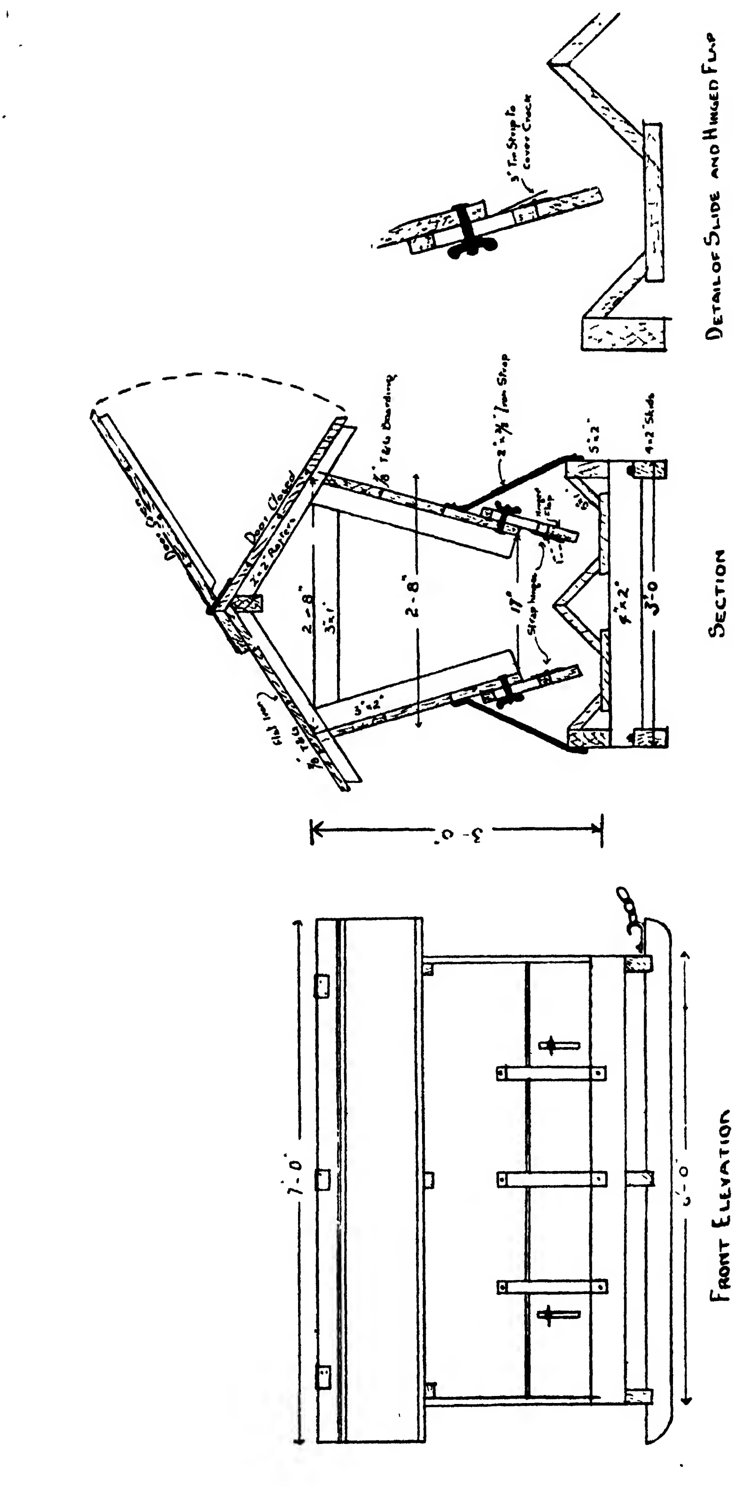


Fig. 22.
Details of Self-Feeder described on page 502.

CONSTRUCTION OF SELF-FEEDER.

1. *The Feed Trough.*

The self-feeder rests on two 4in. x 2in. skids provided with two strong flat iron draught lugs, which render it portable.

Three 4in. x 2in. bearers are then notched over the skids. On top of these bearers the feed trough is formed, the bottom being 10in. x 1in., and the sides 5in. x 2in. on edge bolted to bearers with ⅜in. bolts through the skids and bearers. Two pieces of 8in. x 1in. wood placed at 45 degrees form the centre or back of both troughs, and two pieces of 5in. x 1in. wood placed at 45 degrees from the 5in. x 2in. side-pieces to the bottom board complete the feed trough.

2. *The Bin.*

The bin, or hopper, is constructed of wood. The frame is made of 3in. x 2in. uprights with 3in. x 1in. across the top; rafters of 2in. x 2in. and 4in. x 2in. ridge. The top is sheathed with 6in. x ⅞in. tongue and grooved boards; one side of the top acts as the door, which is composed of 6in. x ⅞in. tongue and grooved boards with two 6in. x 1in. ledges. The door and top are covered with flat iron; hinge door with three strap hinges.

The top should project well over the trough, so that water will not drip into it. The sides and end of the bin should be sheathed with 6in. x ⅞in. tongue and grooved boards. The bin is supported by 2in. x ⅜in. iron straps bolted to trough and to bin.

The slide and hinged flap are regulated with a slot and bolt and screw; the bottom of the slide is hinged with strap hinges. The slide is 8in. x 1in. wood, the flat 4in. x 1in. wood, with a strip of tin or light iron 3in. wide to cover the crack.

The whole structure measures 6 feet long by 3 feet wide, the eaves projecting 6 inches all round.

Thinning as Related to the Acquisition of Apples and Pears.

H. R. POWELL, Superintendent of Horticulture.

The announcement by the Assistant Minister for Commerce, Mr. H. L. Anthony, as set out hereunder, that apples and pears of prescribed varieties and grades, with size limitations, will be acquired under the National Security (Apple and Pear Acquisition) Regulations, is of particular interest to fruit growers in this State.

Accepting the viewpoint that pre-war incomes may be seriously reduced by restrictions of exports imposed by the shortage of shipping space, it is necessary to take the view that some steps can be taken to alleviate the position by the grower himself. I mean the grower, by judicious thinning, cultivation and orchard hygiene, can do much to ensure, with anything like favourable weather conditions, that the bulk of his crop will be acquired.

Last season, assessments were made in January by officers of this branch and in cases where the fruit was unthinned and of poor size (mostly Yates and Doughertys), the assessment was deferred until the required attention was given. Unfortunately, weather conditions were so severe that many hundreds of cases of fruit could not be marketed on account of being under size. This loss was most noticeable on those orchards where adequate thinning operations had not been carried out.

This season the "assessments" or "appraisements" will in all probability be carried out in February for the mid-season varieties and it seems certain that fruit not coming up to the minimum size requirements will be excluded from the assessment. This will mean a heavy loss to those growers who could have done much to prevent it.

It must be remembered that thinning is not an additional burden on orchard costs, as it means that the fruit thinned from the trees is handled only once before it is dropped on the ground. If it is left on the trees, however, the small fruits are a loss to the grower, a burden for the trees, and they will have to be ultimately removed from the trees, particularly in those districts where Fruit Fly is prevalent.

A study of the Schedule shows how unprofitable it will be to grow apples of small sizes, particularly Yates, Doughertys and Cox's Orange Pippin. "Extra Fancy" and "Fancy" grades of these varieties, minimum size 2¼ in., quality for advances of 3s. per bushel, whilst apples of the same grade of 2⅛ in. size, only qualify for advances of 2s. per bushel, and "Good" grade of 2⅛ in. size, will not qualify at all for advances.

The minimum size for the other varieties of apples is 2¼ in., except that in (b) group 2 of the schedule it is 2½ in. for varieties such as Ballarats, Prince Alfreds, etc.

ACQUISITION OF APPLES AND PEARS.

Information regarding the conditions under which advances will be made to growers on apples and pears of the 1940-41 crop which is to be acquired by the Commonwealth, has been made available by the Assistant Minister for Commerce (Mr. H. L. Anthony).

Details showing the classification of the varieties of apples and pears into groups, the prescribed grades and sizes qualifying for compensation advances, and the rates of the advances for fruit in this State are set out below:—

APPLE AND PEAR ACQUISITION—1940-41 CROP.

APPLES—Varieties, Qualifying Sizes and Rates of Advance.

Western Australia.

Group 1—Varieties—

(a)	Delicious	Democrat	Granny Smith
	Jonathan	Gravenstein	Legana
	Beauty of Bath	Williams Seedling	Willie Sharp
	Carrington	Kirk's Seedling	Cowell's Red
	Cleopatra	Peasgood	Twenty Ounce
	Mobb's Royal	Lady Daly	Trivett
	Lord Nelson	Warner's King	

X.F. and Fancy	Good.
2¼ in. minimum,	2¼ in. minimum,
3s.	2s.

Group 1—*Varieties* (*continued*)—

(b) Cox's Orange Pippin	Crofton.	Dougherty.	Yates.
X.F. and Fancy 2¼ in. minimum, 3s.	X.F. and Fancy. 2⅛ minimum, 2s.	Good. 2¼ in. minimum, 2s.	Good. 2⅛ in. minimum, not qualifying.

Group 2—*Varieties*—

(a) Australian Beauty	Scarlet	Tasman's Pride
Geeveston Fanny	Golden Delicious	King Cole
Duke of Clarence	Nickajack	Rokewood
Stone Pippin	Sturmer	Dunns
Rome Beauty	McIntosh Red	Statesman
Stayman	Worcester	

X.F. and Fancy 2¼ in. minimum, 2s.	Good. 2¼ in. minimum, 1s.

(b) French Crab	Ballarat (Stewart's Seedling)	Alfriston
London Pippin	Prince Alfred	

X.F. and Fancy. 2½ in. minimum, 2s.	Good. 2½ in. minimum, 1s.

Group 3—*Varieties*—

Alexander	Ben Davis	Pomme de Neige
Ranelagh	Pioneer	Schroeder
Wellington Pippin	Yapeen	Coleman
Auradell	Crow Egg	Spitzenberg
King David	King Pippin	Newton Pippin
Ribston Pippin	Strawberry Pippin	Buncombe

X.F. and Fancy 2¼ in. minimum, 1s.	Good. Not qualifying.

Any other varieties or sizes required for marketing will be compensated on a basis of quality and size to be determined.

A schedule for pears in Western Australia is not included as the grouping has not yet been finally determined.

Compensation in each group is provided for fruit of "Extra Fancy" and "Fancy" quality. Fruit of "Good" grade in a particular group will rank for compensation on the basis of "Extra Fancy" or "Fancy" grade in the next lower group.

The acquisition will relate only to pears for sale as fresh fruit; quantities delivered to canneries for processing will not be acquired.

Compensation will be paid to growers of fruit actually delivered to the order of the Minister or of the Marketing Committee. Fruit produced suitable for delivery if not required, will be compensated subject to the approval of the Minister.

Growers will be required to harvest their fruit and provide containers for harvesting where such are distinct from containers for storage or sale. It will also be necessary for growers to transport such fruit and containers either to the gate of the property on which the fruit is grown, or to such other point closer to the trees as may be directed.

As to any further services and materials which growers may be directed to provide in effecting deliveries, the costs involved will be recouped at rates to be determined.

To ensure that usual sources of finance for crop production and marketing are not withdrawn through undue uncertainty as to payment, arrangements will be made for the payment to merchants from advances, or other amounts due to growers from time to time, amounts claimed by merchants and authorised by growers. It is intended, however, that such payments to merchants will be restricted to amounts advanced by merchants and declared as having been for either production costs or delivery or marketing costs of the crop of apples and pears produced between 1st August, 1940 and 31st July, 1941.

Dairy Premises.

G. K. BARON-HAY, Superintendent of Dairying.

The following notes and diagrams are intended to convey to those dairy farmers desirous of constructing dairy premises the minimum requirements necessary for compliance with conditions for the supply of cream to Dairy Produce Factories, and plans for buildings considered suitable to West Australian conditions.

It is pointed out that the plans submitted are not laid down as those which must be adhered to, but are intended to act as a guide to those farmers desiring to erect new premises or who may be required by Inspectors to alter the structure of existing buildings. Because of this, specifications are not attached to these plans, as such can be drawn out by any firm supplying the material which it is intended should be used in the construction of the buildings, and in very few instances do farmers build premises exactly according to plans and specifications, as their requirements and the lay-out of the surroundings may not be convenient in standard plans.

Whatever plan is adopted ultimately, there are certain principles to which the owner must adhere in order to conform with the regulations and to provide for the production of milk and cream under hygienic conditions.

Climatic Influences.

In the wetter regions of the State, it is advisable to construct buildings of materials which will withstand the wet winter so as to avoid the necessity of replacements for many years, and in this connection galvanised iron has been found most suitable, although jarrah—provided this is painted or treated periodically—will withstand climatic conditions for a considerable period. In wet periods, muddy yards are often a cause for contamination, and, during the summer months, dust—particularly from the assembly yard—is undesirable, as both have an adverse influence on the quality of the milk and cream produced.

In constructing the yards, therefore, the direction of the prevailing winds should be borne in mind, and the separator room and milk room should be protected as much as possible from dust or odours which are likely to occur in the yards or milking shed.

The attached lay-out of dairy premises for several types of bails indicates the essential items which should be borne in mind.

Because of the winter weather conditions, it generally will be found most suitable if milking sheds face east or south, the weather coming from the west and north during winter months. In the milking bails an endeavour should be made to aim at protection from prevailing winds.

Dusty Walls and Ceilings.

The interior surfaces of the walls and ceilings of the separator and cream storage room should be kept clean and free from dust which is laden with undesirable germ life.

Dust can be removed from the walls and ceilings either by water from a hose or by means of a damp cloth or mop.

Protection of Milk and Cream against Flies or Vermin.

All vessels in which milk or cream is held in storage should be covered by a wire metal gauze of a mesh so fine as to prevent contamination by flies or other vermin.

Precautions in Milk or Cream Room.

Calico, hessian, bagging, or paper, etc., must not be hung or fastened to the walls or ceiling of the cream room. Sour or skim milk or whey should not be kept in the cream room or its vicinity, and the utensils used to contain or convey them must be thoroughly washed and scalded immediately after use.

The Separator Room and Cream Room.

In regard to the separator room—whether erected adjoining the bails or a separate building—care should be taken to provide the most efficient system of ventilation by means of the prevailing winds.

As the separator room is a closed structure, the gable roof should be constructed so that the prevailing wind can blow through one end of the gable to the other, which would be at right angles to that selected for the bails. Therefore, the gables of the separator room usually will face north and south, in order to provide for better ventilation.

Lining the Walls.

The lining to the walls of the separator and cream storage room is optional, provided the internal surface of the walls is smooth and the material from which it is constructed free from projections, knots, etc. The provision of a double wall is preferred, as this provides for greater cooling. Where it is not intended to provide a double wall, then the uprights of the frame work of the cream room should be on the outside of the material used for the wall.

Size of Separator and Cream Room.

While the regulations provide that the cream room shall be at least six feet square and eight feet in height, in practice—except where small herds are handled—this will be found to be inadequate.

The following minimum sized rooms are recommended according to the various sized herds:—

	Size of Room.
20 Cows or more	12 ft. by 10 ft. by 10 ft. high.
10 to 20 Cows	8 ft. by 10 ft. by 10 ft. high.
10 Cows and under ..	6 ft. by 6 ft. by 8 ft. high.

For ventilation purposes such milk and cream storage rooms should have openings or air vents in at least two walls, the openings to be at least six inches wide at a height of six inches above the floor level and should face towards the direction from which the prevailing winds come. In order to prevent dust, such openings can be protected by a six inch hood or awning. For preference, the ceiling or lining of the roof should follow the contour of the roof, which should be provided at the apex with an air ventilator or cowl of eight inches diameter.

Diagram 1.

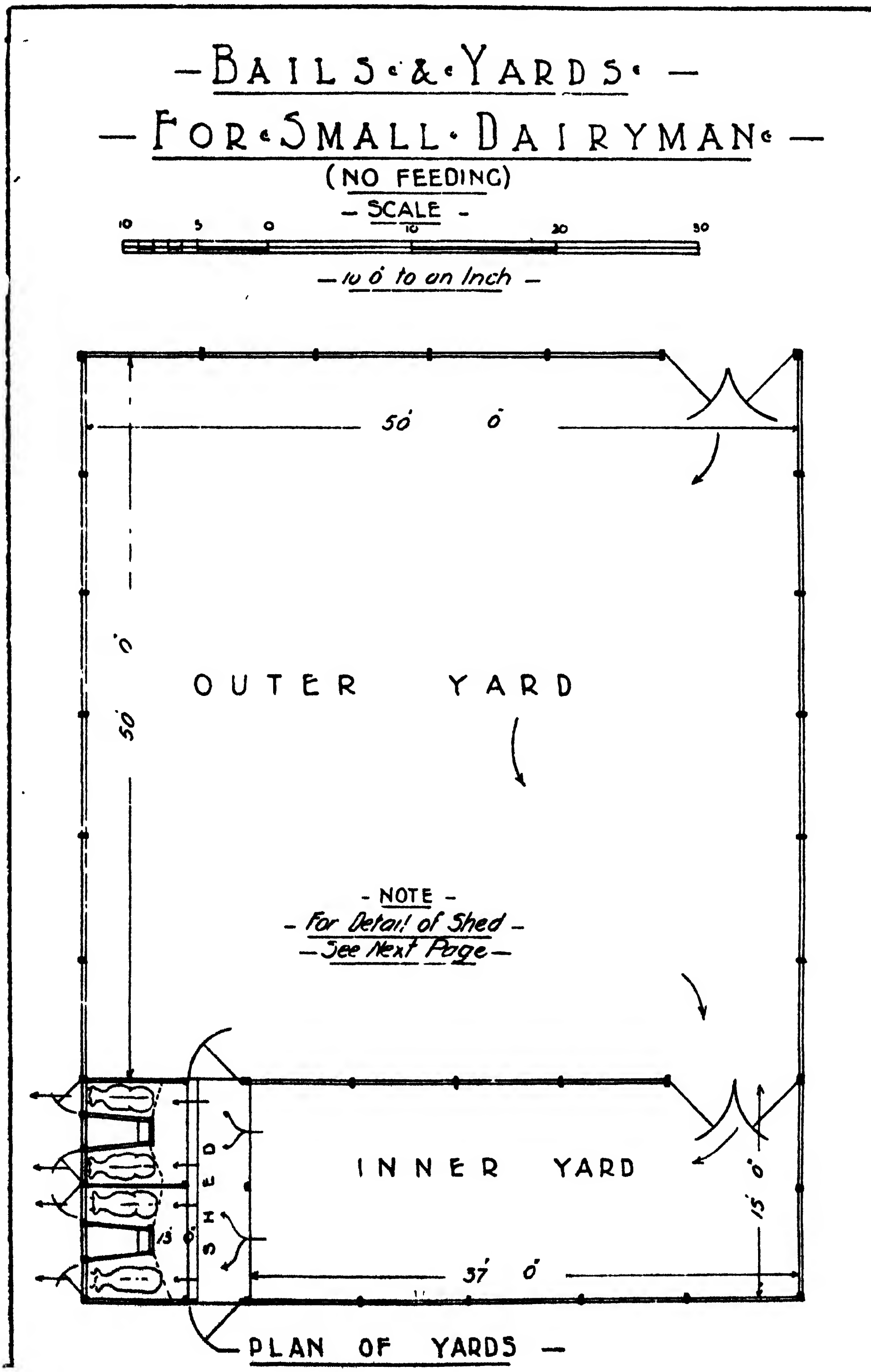
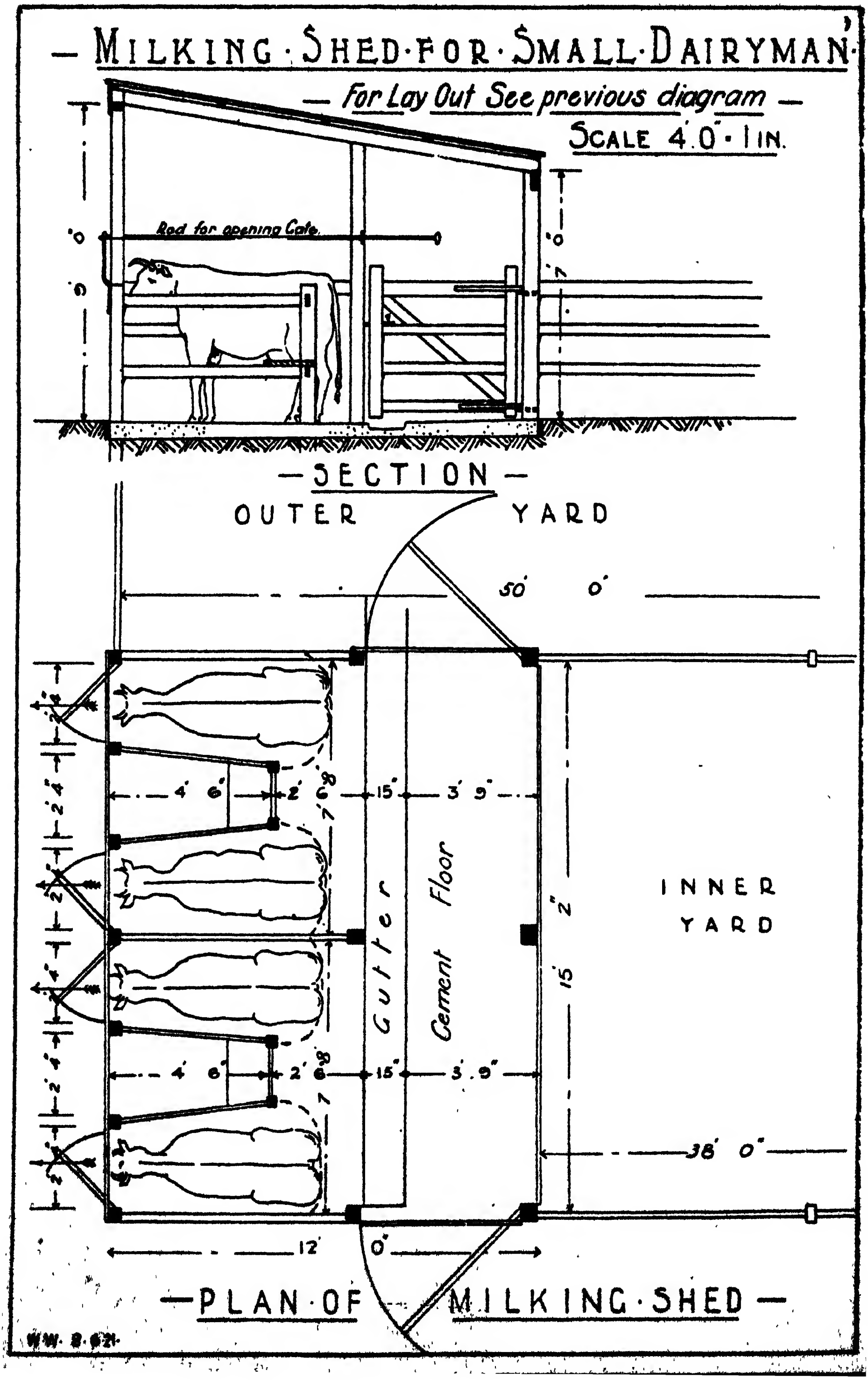

BAILS & YARDS
FOR SMALL DAIRYMAN
(NO FEEDING)
SCALE
10 5 0 10 20 30
10' 0" to an Inch
50' 0"
50' 0"
OUTER YARD
NOTE
For Detail of Shed
See Next Page
SHED
INNER YARD
15' 0"
13' 0"
37' 0"
PLAN OF YARDS

Diagram 2.



— MILKING · SHED · FOR · SMALL · DAIRYMAN ·
— For Lay Out See previous diagram —
SCALE 4'0" · 1 IN.
Rod for opening Gate.
— SECTION —
OUTER YARD
50' 0"
4' 6"
2' 6"
7' 8"
15"
3' 9"
Gutter
Cement Floor
15' 2"
INNER YARD
38' 0"
12' 0"
— PLAN · OF MILKING · SHED —

Diagram 3.

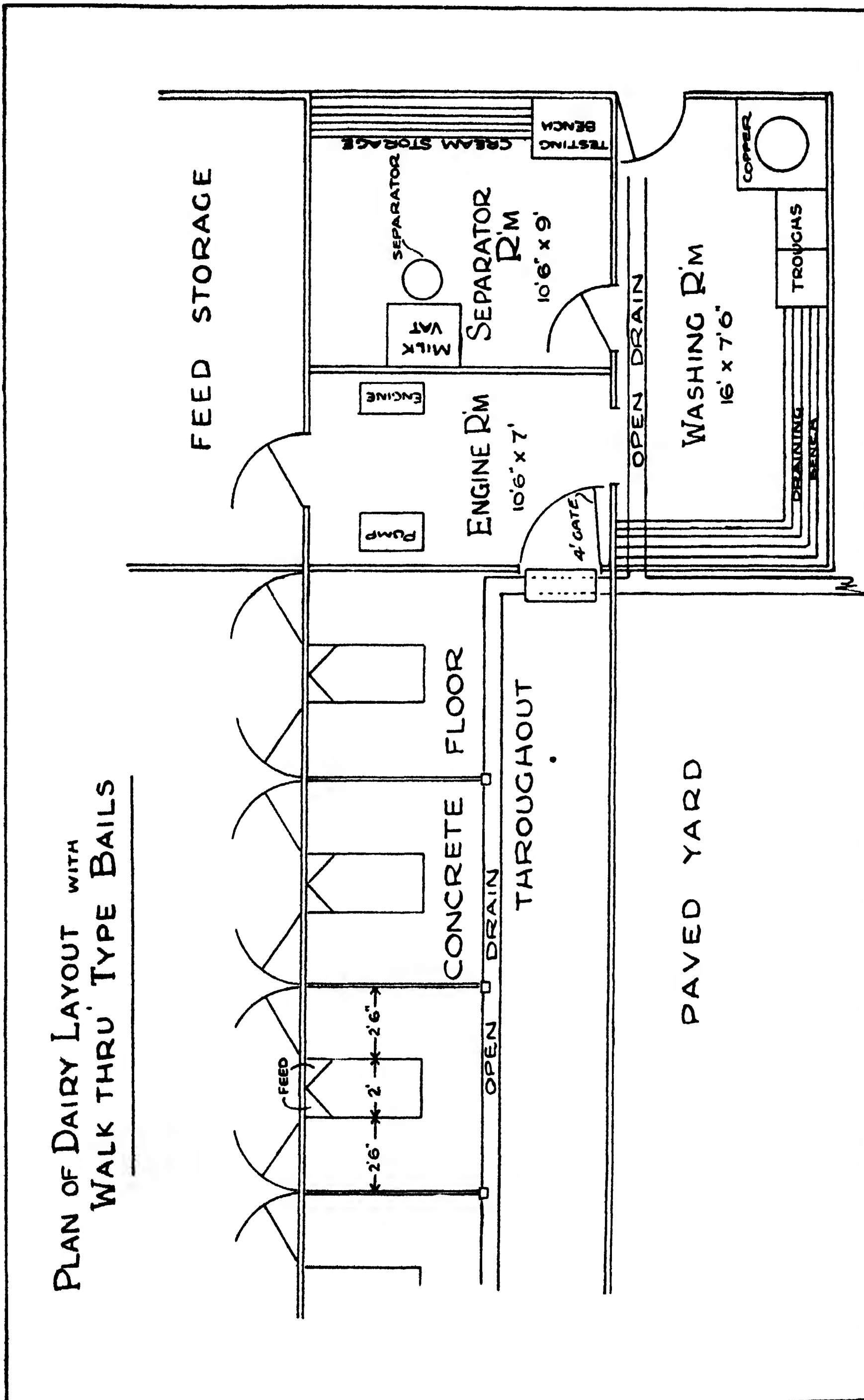
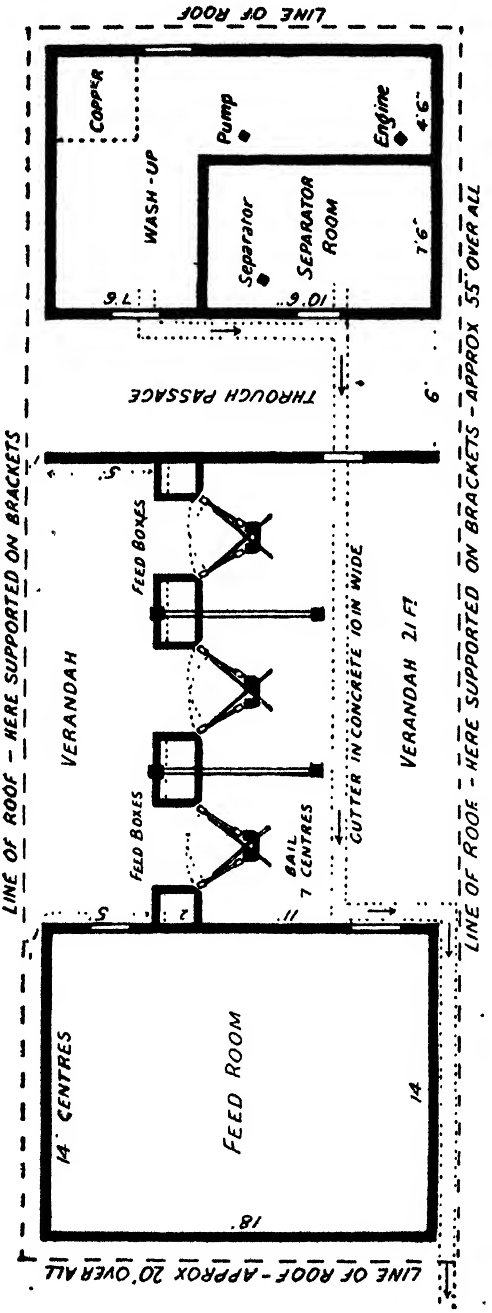
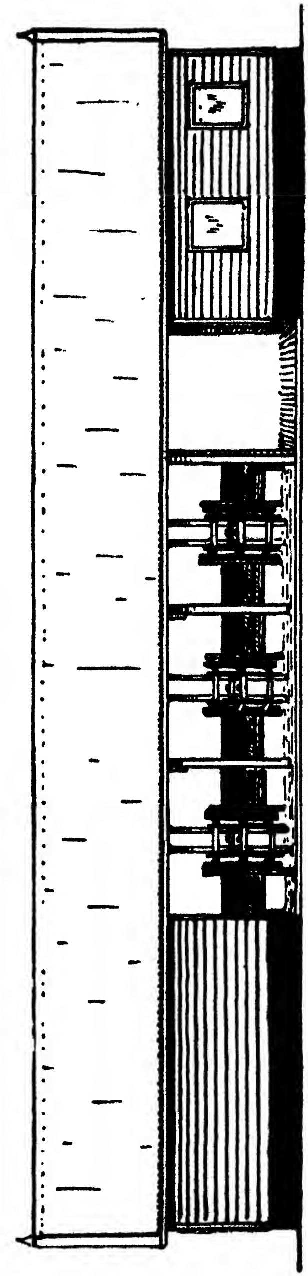

PLAN OF DAIRY LAYOUT WITH
WALK THRU' TYPE BAILS
FEED STORAGE
CREAM STORAGE
TESTING BENCH
SEPARATOR
MILK VAT
SEPARATOR R'M
10'6" x 9'
ENGINE
PUMP
ENGINE R'M
10'6" x 7'
4' GATE
OPEN DRAIN
WASHING R'M
16' x 7'6"
COPPER
TROUGHS
DRAINING BENCH
FEED
2'6"
2'
2'6"
CONCRETE FLOOR
THROUGHOUT
OPEN DRAIN
PAVED YARD

Diagram 4.

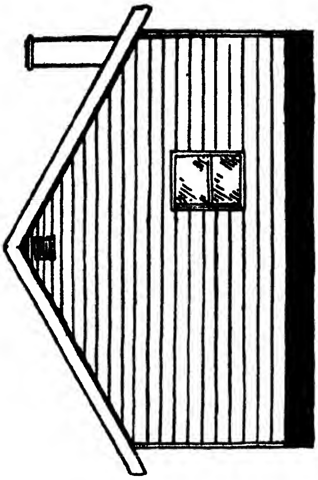


Ground Plan.

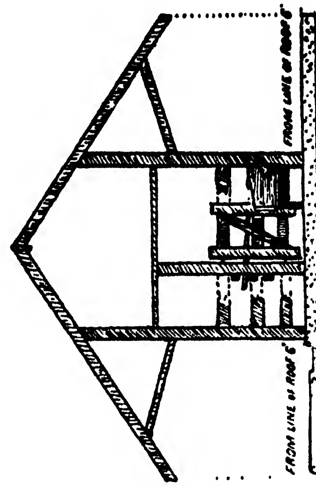


Elevation-View from Rear of Bails.

[Vict. J. of Agric.]



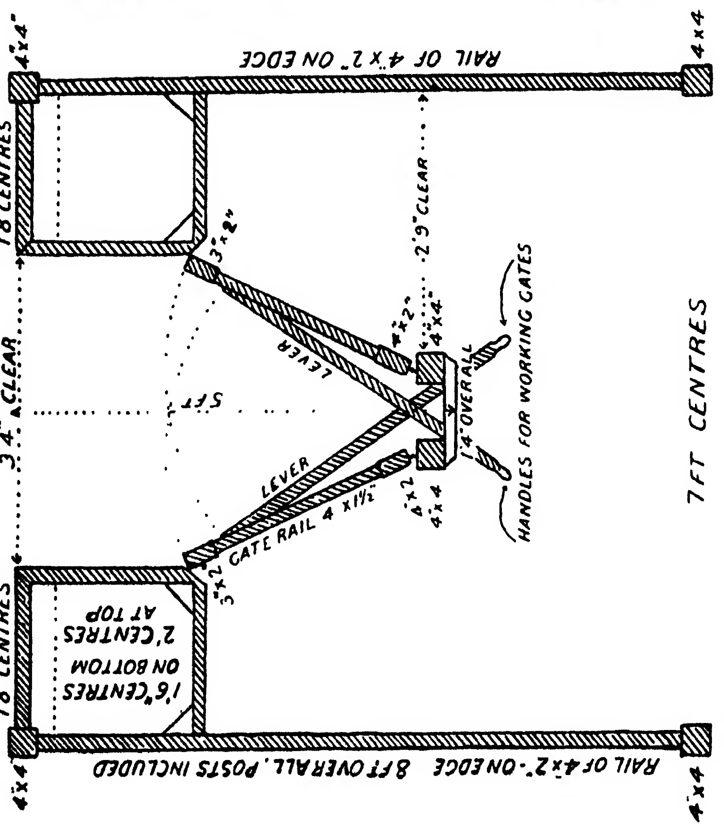
END ELEVATION (DAIRY END)



SHOWING BAIL ARRANGEMENT AND BRACKETED RAFTERS OVER SAME

[Vict. J. of Agric.]

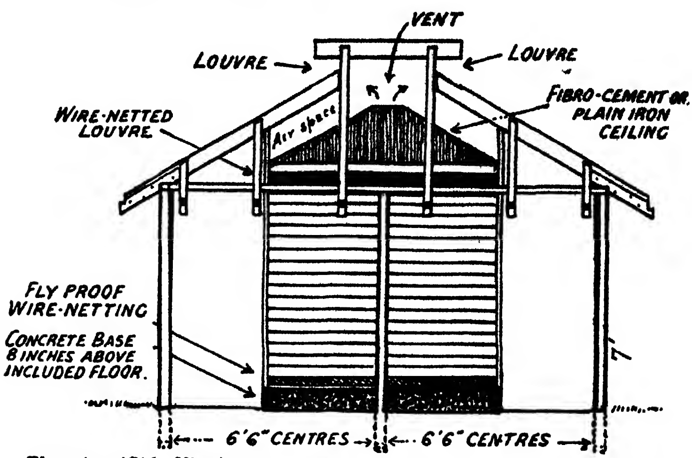
Diagram 5.



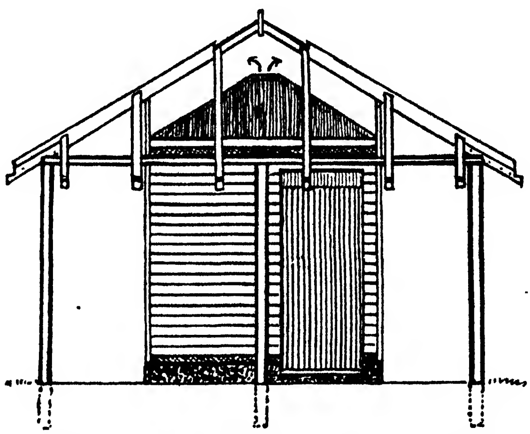
Detail Construction of Walk-through Bail.

Diagram 6.

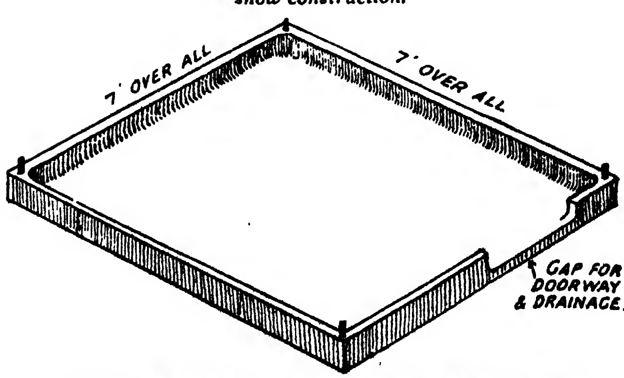
CREAM STORAGE ROOM.



Elevation (Side View) with roofing removed to snow construction.



Elevation (Front View) with roofing removed to show construction.



Showing raised edge of floor in concrete ready to receive wall plates and inset bolts for same.

[Vict. J. of Agric.]

Diagram 7.

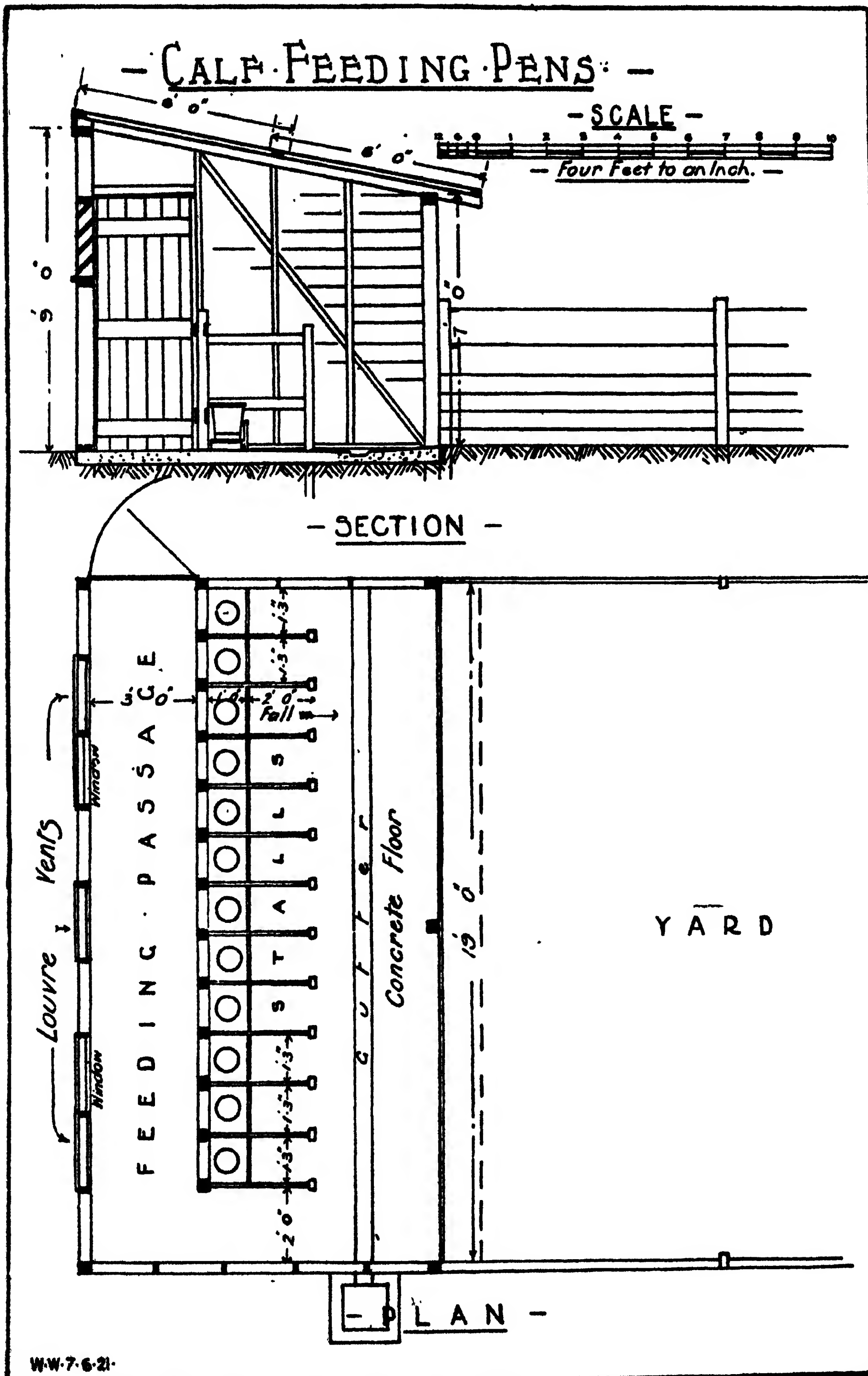
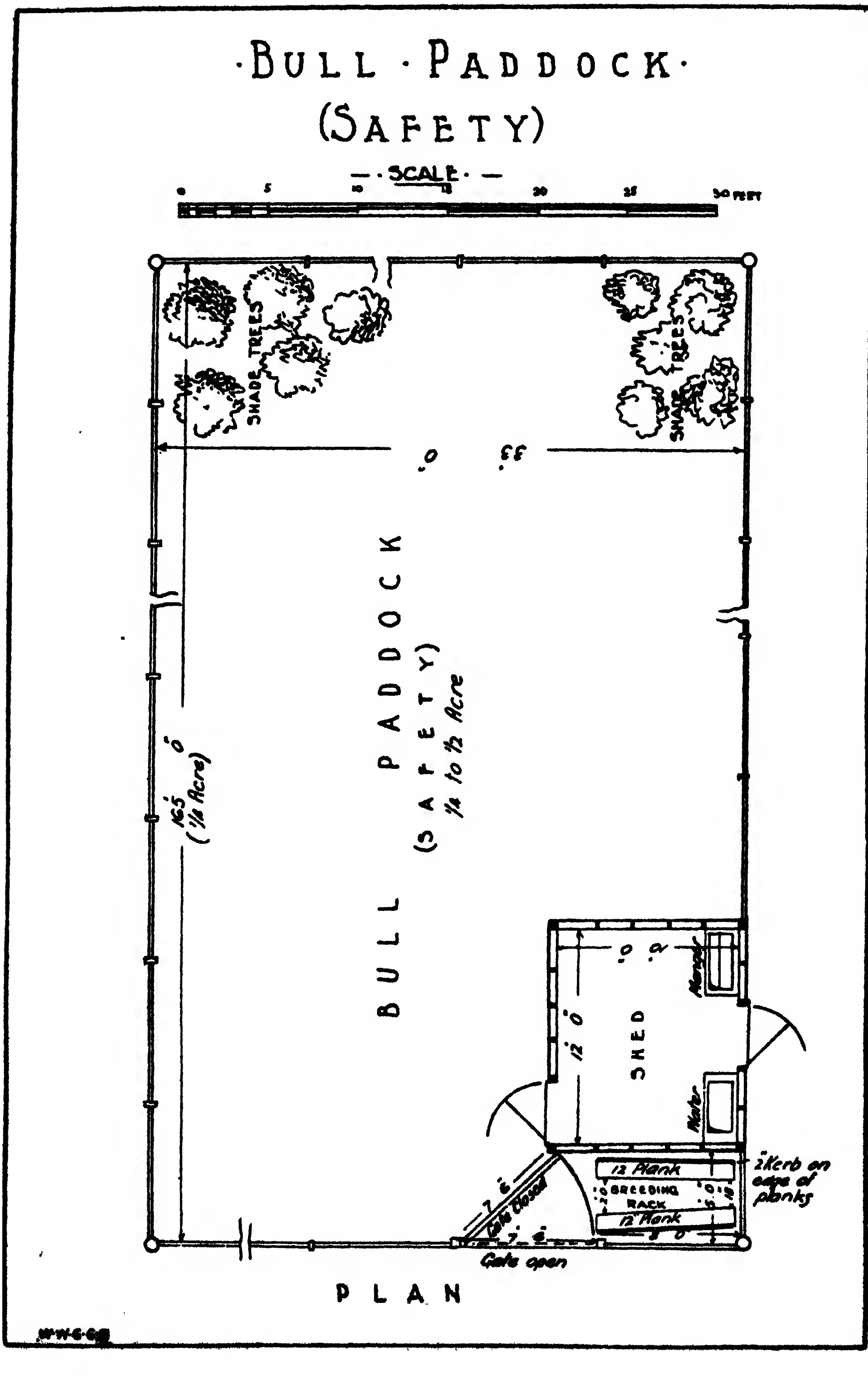

CALF·FEEDING·PENS
SCALE
Four Feet to an Inch.
6' 0"
6' 0"
9' 0"
7' 0"
SECTION
FEEDING · PASSAGE
STALLS
GUTTER
Concrete Floor
Louvre Vents
Window
Window
3' 0"
1' 0"
2' 0"
Fall
13' 0"
2' 0"
YARD
PLAN
W·W·7·6·21·

Diagram 8.


·BULL ·PADDOCK·
(SAFETY)
SCALE
0 5 10 15 20 25 30 FEET
SHADE TREES
SHADE TREES
33' 0"
BULL PADDOCK
(SAFETY)
1/4 to 1/2 Acre
165' 0"
(1/8 Acre)
SHED
12' 0"
Manger
Water
12 Plank
BREEDING
RACK
12 Plank
Kerb on edge of planks
Gate Closed
Gate open
PLAN

SUMMARY OF REQUIREMENTS.

1. Every stock yard and dairy premises used by any dairyman shall be properly drained.

2. Stables used for horses shall be disconnected from the dairy premises, that is, be under a separate roof and be at least 50 feet distant from the milking shed, milking room, or dairy.

3. No animals other than dairy cattle are to be kept or allowed in the milking shed.

4. No dung, offensive liquid, or noxious matter of any kind is to be permitted to accumulate or remain upon the premises.

Premises include stock yard around milking shed, and dung should be cleaned from the milking shed and the stock yard daily. A useful method—and one which ensures that this valuable material finds its way again on to fields—is to have a sled in a convenient position away from the milking shed, which is used for placing the manure upon daily. When this sled is conveniently full, it may be drawn out on to the paddocks and the manure rapidly spread. This prevents an accumulation which may require days of work to remove, and also provides that manure is returned quickly to the land without great loss of fertilising ingredients.

5. Fowl houses or enclosures for fowls are not permitted within 50 feet of any milking shed, milk room, or dairy.

6. No live poultry are permitted in the milking shed, and an Inspector may require same to be confined within approved enclosures.

7. No piggery or enclosure for pigs is permitted within 200 feet of any milking shed, milk room, or dairy. This also means that pigs are not permitted to roam on or around dairy premises.

8. No lavatories are permitted within 50 feet of a milking shed, milk room, or dairy.

9. The regulations require that cows must be milked in an approved milking shed which has a water-proof roof, and that the lowest part of this roof shall be not less than 7 feet above the floor level.

The practice of milking cows in the open, which is still followed by several of the older established farmers in the South-West, is to be discontinued.

10. The floor of the milking shed and also the dairy must be of non-absorbent materials on a solid foundation, evenly graded, the fall being away from the feeding trough and leading into open impervious drains running the full length of the shed and wide enough so as to be cleansed readily with a broom. The lowest portion of the floor shall not be less than three inches above the adjoining ground.

11. The drains or channels are to be carried at least 20 feet from the shed or dairy, or such further distance as may be advised by the Inspector to ensure adequate disposal of the drainage matter. Where necessary, these drains shall discharge into an impervious receptacle sufficient to hold one day's flow of drainage and which shall be emptied regularly.

12. The bin for mixing fodder is not permitted in the milking room.

13. Every dairy farmer must provide a room in which to store milk or cream, complying with the following provisions:—

(a) If room is detached, it must be at least 10 feet from the milking shed.

In the case of milking machines, however, the milk room may be under the same roof as the milking bails but shall be separated therefrom by an impervious wall and also separated from the engine room.

The dairy in which the cream is stored must still be at least 10 feet from the milking shed.

Provided the separator and cream room is built in accordance with the plan for the district and the cream room meets the approval of the Inspector, this may be incorporated under the one roof.

(b) It shall be at least 6 feet square and 8 feet in height from the finished floor to the lowest part of the roof or ceiling.

(c) The floor, as in the case of the milking shed, is to be constructed of impervious material which is at least 6 inches above the adjacent ground. Drainage also must be adequate as in the case of the milking shed.

(d) The room shall be ventilated and lighted sufficiently.

(e) Exterior openings are to be fitted with fly-proof screens.

(f) The walls and roof shall be constructed of approved materials unless constructed of stone, brick, or concrete.

Approved materials are asbestos preparations, iron, or wood, and an Inspector may require same to be painted where necessary.

(g) The internal wall surfaces, the ceiling, or, in those cases where a ceiling is undesirable, the underside of the roof shall be covered with hard, smooth, and impervious material, such as asbestos or smooth iron; wood is unsuitable. Such wall shall be finished so as not to afford any lodgment for dirt.

(h) Any shelves, benches, racks, etc., shall be made of smoothly dressed wood or other approved material and so arranged that they may be removed for cleansing purposes. Iron piping has proved both sanitary and convenient for the making of shelves and racks.

(i) The milk room or dairy shall not be used for any purpose other than the handling or housing of milk and the storage of milk vessels.

(j) The farmer, when required to do so, shall pave the ground immediately surrounding the milk room with a layer of not less than three inches of approved material and to a width of at least six feet.

(k) The room shall be equipped with milk strainers of approved material and design, and with an approved cooler which shall be properly connected with a cold water supply.

(l) Every dairy farmer is required to maintain his buildings, drains, fittings, machinery, utensils, tools and appliances in good repair and in a cleanly condition.

(m) Every vessel, receptacle, utensil, or other article used for manipulating milk must be thoroughly cleansed immediately after it has been used, and sterilised with steam or clean boiling water immediately before again being used. This is most important and infers that a liberal supply of boiling water will be available at the dairy for cleansing purposes. The minimum that will be accepted is a copper which is used for the provision of boiling water and is situated at the dairy.

The practice of boiling water some distance from the dairy and carrying this out to the place selected for washing dairy equipment is to be discontinued.